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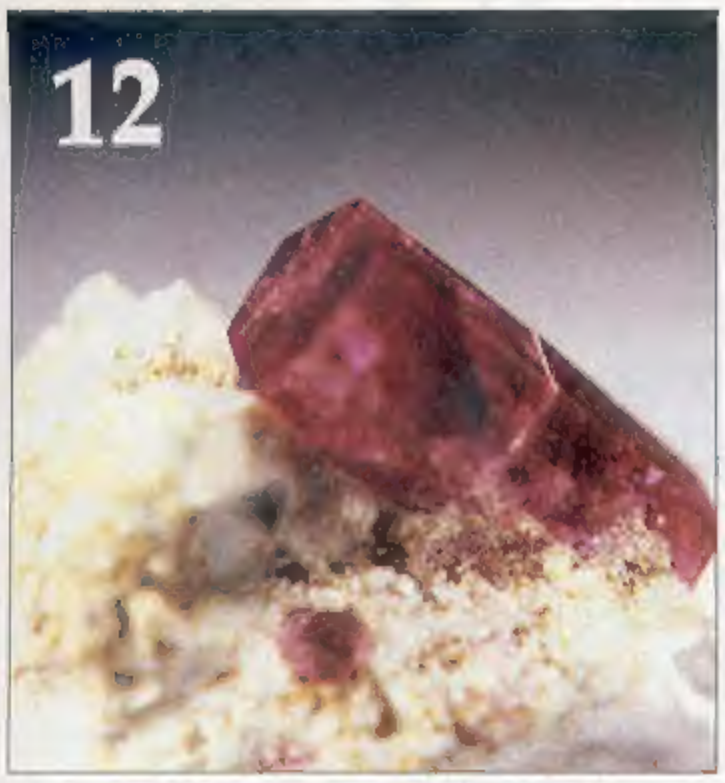

COVER: The contrasting relationship of red beryl from the Wah Wah Mountains of Utah (Harris collection) to Colombian emerald (green beryl) symbolizes Taoist philosophy in gemstone jewelry. (Harold and Erica Van Pelt photos)

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THE YIN-YANG OF BERYL

by Bob Jones

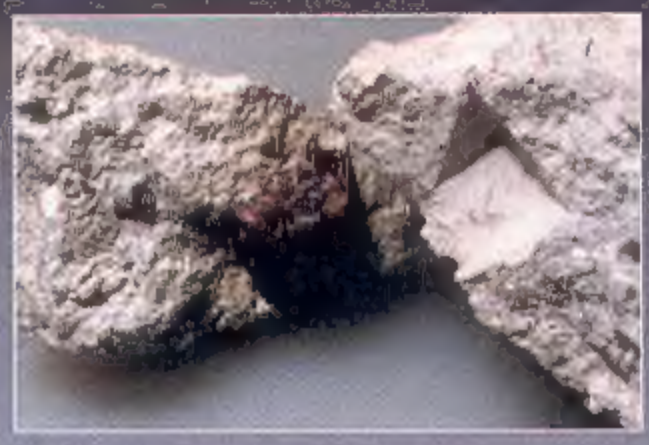
The various colors of beryl, along with its hardness and other useful properties, are responsible for its popularity as a gem and have led to its various names. Beryl that is not gemmy is generally called common beryl. But for the gemmy crystals we invoke various names, some comparing the color to something we know. We invoke the color of blue water when we call beryl aquamarine. When the crystal is yellow, we use a sunlike name, heliodor. We depart from nature when we call pink beryl morganite, after banker J.P. Morgan (thanks to George Kunz, who benefited from Morgan's financial support). When the crystals are colorless, we name them goshenite for the town where the first such beryls were found, Goshen, Massachusetts. Green emeralds, if they lack chromium or vanadium as a color activator, are simply called green beryl. But throw either of those two elements into the beryl chemical mix, and we refer to the luscious green stones as emerald. We commonly use emerald's color in our everyday language and emerald's nicknames always use its color, as in green bolts or *Green Fire*, the title of a book on the emerald mines of Colombia.

Emerald's name hearkens back to ancient times when green crystals of any species were called smaragdus, a Perisan word. For years, I wondered how anyone could arrive at the word "emerald" from such an odd ancient word. It seems that smaragdus eventually morphed into esmeraude, which evolved into emeraude, then esmeralde. Close enough!

Until a few decades ago, the beryl family lacked a bright-red member. When first found in the Thomas Range of Utah, the tiny red crystals were called bixbite. The crystals were exceedingly small and not suited to faceting, but this was the first time beryl with a true red color had been found, a mineralogical oddity. Eventually, bixbite was dropped as a name for red beryl, and since that time no one has come up with a legitimate moniker for it. Bixbite was named for Maynard Bixby, the fellow who found the small red crystals in the Thomas Range. However, Bixby also found an attractive black cubic mineral, a new species, later named bixbyite, a manganese iron oxide. You can see now why naming red beryl bixbite was an ill-conceived idea.

The red beryl from the Wah Wah Mountains was found in large enough crystals to provide nice faceted stones of decent size, and has brought a whole new jewelry philosophy into the marketplace. It can be coupled with green emerald, both members of the beryl family, in a delightful contrasting relationship. This

Red Beryl Is Now Available in Quantity



A sharp cast of this beryl crystal can be seen in the rhyolite matrix. (Photos by the author)

The color in all red beryl is due to the element manganese acting as a chromophore (J. Barlow collection).

Red beryl crystals don't get much bigger than this 2-inch doubly terminated beauty.

The rich green color of emerald is caused by the trace metal element chromium.

relationship goes far beyond a nice piece of red and green jewelry that would be an ideal Christmas gift for the wife. In the Orient, putting red and green beryl together has a much more philosophical meaning. By combining the two stones of similar chemistry but opposite colors, the jewelry enters the world of ancient Taoist philosophy and religion.

This philosophy is represented by a very simple symbol called Yin-Yang. The design is fairly commonly seen; it is a circle halved into two equal areas by an S-shaped line. One side is black with a white dot, the other white with a black dot. Whether you realize it or not, this simple and attractive symbol actually represents the important philosophical and religious beliefs of Taoism.

Taoism is a philosophy and religion that took root about 600 B.C. It teaches that we should conform to a cosmic order with simplicity of social order and political organization. The philosophy is based on recognizing opposites. It represents the dual principle of universal life and creation, and works through what are recognized as the five elements: fire, earth, water, metal, and wood. These five Taoist elements were related to the five known planets of that time. The basis of all this is expressed through that very simple design called Yin-Yang, the opposites we see in the world.

According to Taoism, one side of the round black-and-white symbol represents the female, the Yin. The other side represents the male, Yang. Yin represents the negative in our lives and Yang the positive. Yin symbolizes the moon and Yang represents the sun. So what do red and green beryl have to do with Yin-Yang? If Yin-Yang represents the opposites of Taoism, jewelers can use red beryl to represent the opposite of green beryl. It is a simple and obvious relationship to combine the two into jewelry that would symbolize Yin-Yang.

That's exactly what has happened in the Orient, where Taosim is still an important part of people's lives. This pairing of red and green beryl was only possible once a good supply of gem red beryl finally became available. When that happened, jewelry sales boomed and the demand for red beryl skyrocketed. After all, there are dozens of sources of emerald, but only one area that produces facet-grade red beryl: Utah's Wah Wah Mountains!

Naturally, even though I'm not a Taoist, I felt I had to visit a red beryl mine. I'd already been underground in about six different emerald mines in Colombia, the world's best source for gem emerald. A visit to a red beryl mine would complete my Yin-Yang collecting cycle.

The only known sources for red beryl are an insignificant spot in New Mexico, a slightly more important spot in Utah's Thomas Range, and a profoundly important spot in the Wah Wah Mountains. My desire to collect red beryl was not fulfilled until 2004.

It's funny how these things work. I had already been to Utah when I worked on the video "Collecting Earth's Natural Treasures." I even spent time with Rex Harris, noted red beryl miner and promoter. But I did not visit his Ruby Violet red beryl mine near Milford, Utah. Up until recently, this deposit was the only significant source of red beryl. Harris had mined the largest and finest red gems available. So for a time after that Utah video shoot, I had put aside a desire to dig red beryl.

Then I had a phone call. It turned out to be a former science student of mine who had been in my school rock club maybe 25 years ago. Clay Holman had seen my picture in *Rock & Gem* and called me. We had a nice chat, and during the call he suggested I visit a red beryl mine where he works. Say no more! A trip was arranged in May 2004, and my son Evan and I headed into red beryl country.

We rendezvoused with Clay in the farming town of Milford, Utah, about 25 miles east of the Wah Wahs. Clay had worked at the mine and was a good friend of one of the owners, who had given his OK for us to visit the working property. Being allowed into a working gem mine of any kind is a bit unusual!

The night we arrived, wind was raging through the area, often exceeding 50 miles an hour. But our collecting day dawned bright and sunny. Over breakfast, we met with Clay and another fellow, Tom Munson, who is with the Department of Oil, Gas and Mining. Tom was scheduled to go to the mine on an inspection tour, and had chosen to join us on our visit to the Red Emerald claims. Tom is extremely knowledgeable about Utah mining and was a big help in understanding the deposits we visited.

continued on next page

Red beryls seldom yield a faceted gem larger than 2 carats.

Emeralds from Muzo, Colombia, almost always occur in a white calcite.

The Yin-Yang of Beryl *from page 13*

We convoyed to the mine. It wasn't long before we spotted a glaring white slash across the face of a low-lying, forested hill, part of the southwest end of the Wah Wahs. The slash turned into huge open pits and dumps as we slowly drove up the hillside.

Though red beryl was first found in the Thomas Range north of here, the only viable gem crystals come from this rhyolite formation in the Wah Wahs. The initial discovery here was made by Lamar Hodges, who was prospecting for uranium after World War II. Instead, Hodges found small, red crystals, which were later identified as red beryl. He staked claims and his family enjoyed recreational weekend digging, a marginally successful way to collect the gems. Hodges eventually sold his claims to the Harris family, who started mining more aggressively. Eventually, Rex gained control of the properties, and through skillful and careful mining, mainly by hand, he and his son obtained some amazing crystals. In the meantime, Rex did an expert job of marketing his rare beryl crystals, and it was through his efforts that red beryl gained popularity in the gem world. From there, it was only a small step for gemologists and jewelers to connect red beryl with green beryl to symbolize the Yin-Yang philosophy in Oriental jewelry.

To reach the mining area, we had passed between two large open pits. On the right side was the Harris Ruby Velvet Mine, not operating at the time. On the left was our destination, a working red beryl gem mine, the Red Emerald. What an appropriate name! Owned by Earl Foster and Marlow Cropper, who very generously extended the invitation to dig, this mine has already yielded some remarkable specimens and gems. During one of our breaks from pounding on the very hard rhyolite rock, Marlow pulled a rock out of his truck that measured 15 to 18 inches across. Scattered across the surface of this white slab were dozens of bright-red beryl crystals, the largest matrix specimen of red beryl I had ever seen. The rock was found in an area where we had been digging earlier in the day. It represented one side of a thin seam in the rhyolite. Not surprisingly, the opposite side of that "pocket" was barren!

Digging here is really tough without some heavy equipment, but blasting is ill advised for obvious reasons. Heavy equipment, when used properly, can expose potential areas for hand digging.

The collecting site du jour was a large iron-stained knob of rock in the lower pit. A big machine with a fingerlike steel probe pounded that rock knob to fracture it. Then several of us moved in with hand tools and worked the knob for much of the day. We tore away chunks of the rhyolite, stopping frequently to explore thin, clay-filled seams with little success. There was plenty of brilliantly fluorescent hyalite opal, but red beryls were scarce.

Once in a while, someone would stop hammering, put down the pry bar, and begin working a thin seam of clay. Some seams were lined with hyalite opal, fluorescing green due to an insignificant amount of uranium. Other seams were barren. But once in a while, with careful scraping with a screwdriver or a pocketknife, a small, red hexagon would emerge. It might be a fragment of an incomplete crystal or a complete terminated hexagon maybe ¼ inch long. On rare occasion, it would be gemmy. And even rarer were crystals as thick as your finger and an inch or longer. The best loose crystal we saw from that knob was about the size of your thumb's first joint. Such is the scarcity of this rare gem beryl that, regardless of size, any crystal with a hint of gemminess is carefully bagged.

Just how red beryls formed here was a question that took some study to answer. That they occur in a rhyolite suggests the rhyolite itself was a bit unusual. In a molten state, it had to have had some beryllium and other volatiles in it, unless these elements were introduced by later hydrothermal or vapor action. The rhyolite was emplaced about 23 million years ago and was rich in fluorine, uranium, and the necessary beryllium. While fluorine is necessary for the formation of topaz, as seen abundantly in the Thomas Range, little topaz occurs here. But there was obviously enough beryllium present to create red beryl, a beryllium aluminum silicate. One other element had to be present in at least trace amounts—manganese—as a color activator.

Scientists originally thought the Wah Wah red beryls formed when later hydrothermal solutions had invaded joints in the rhyolite. The process theorized was that these solutions either brought beryllium with them or leached it from the host rock. A hydrothermal leaching process had created the world's greatest emerald deposits in Colombia. This hydrothermal solution theory in the Wah Wah Mountains was later proved wrong.

Today, the theory of choice is that the red beryls formed during the final phases of the rhyolite emplacement itself. As the rhyolite slowly cooled, the small amounts of volatile elements it contained—including fluorine, beryllium, and minor amounts of uranium—remained in a gaseous state. The high temperature of these gases persisted during cooling; they finally invaded whatever cracks and openings were developing in the original rhyolite as it cooled and shrank. These beryllium-rich vapors eventually produced the red beryl crystals. Additional proof of this is that micro crystals of fluorite are encountered close to the red beryls.

The color of these lovely beryl gems is due to trace amounts of a transition metal element, manganese. Manganese is called a transition element because its internal electron arrangement varies according to conditions. There are times when manganese atoms are willing to use two outer electrons in a structure to absorb some light energy. At other times, it will use three electrons. These electrons play a role in the color of a mineral if and when manganese is a trace element, as in the case of red beryl. They do this by absorbing some, but not all, of the color wavelengths that make up white light. As manganese's electrons absorb some energy, they shift their positions. This shift influences the final color seen.

The atoms within the structure of molecules are usually in one of two geometric patterns: cubic or octahedral. The difference in distance between atoms in these two patterns influences the type of light energy absorbed. When manganese 2+ is a trace element in spessartine, it is part of a cubic configuration, using the two electrons that absorb light energy. So in the case of spessartine, manganese 2+ results in the transmitted color of orange.

Manganese can be a trace element in both morganite, the pink variety of beryl, and red beryl, the Yang of Yin-Yang. The molecules in both red beryl and morganite are in an octahedral configuration rather than a cubic arrangement. The manganese in morganite, like spessartine, has a valence of 2+. The resulting visible color is lovely pink. Though manganese is the color activator in red beryl and the internal configuration is still octahedral, the manganese has a valence of 3+. This accounts for an intense red color. This unusual—actually rare—red color in beryl has only been found in the three places mentioned earlier.

As we dug into the hard rhyolite of the Wah Wahs, we were warned that the red crystals can be elusive, since they are often coated with and may even include some of the clay in the seams in which they form. If you're lucky, some of the bright red shows through, and you know you had better drop your hammer and

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get out the knife blade. In our experience, there were times when the red beryl crystals simply fell out of the soft clay as single loose crystals without matrix. Other finds—and they were decidedly infrequent—were not in the clay seams at all, but were locked tightly in the hard rhyolite. Such occurrence was both exciting and frustrating: exciting to see the crystal you had revealed by hard work, but frustrating that the crystal was enclosed in hard rock with only a small corner showing. Collecting like this is akin to finding the proverbial needle in a haystack. Once revealed, it takes very careful work to expose enough of the crystal to create an attractive display piece without popping the crystal out of the matrix or, worse yet, shattering it. For the collector, matrix specimens are the prize. For the lapidary, loose crystals with gemmy sections were the find of the day.

Digging emeralds, the other partner in Yin-Yang jewelry, is quite a different matter. For one thing, there are emerald mines all over the world, which means there are lots of crystals and in larger sizes. And in the Colombian mines, at least, the host rock is soft calcite, carbonaceous limestone, or shale.

My trip to the emerald mines of Colombia was courtesy of Don Bachner and José Vesga, who still mines and sells the green gem. In the El Returno Mine at Muzo, I watched as miners augered into the calcite using electric drills, then applied pry bars to loosen the calcite. When they came across small, yellowish spots of parisite, a very rare cesium mineral found in this type locality and an emerald indicator mineral, they would stop and use small hammers and bars to move forward more slowly.

As soon as an emerald is spotted, mining stops! The miners back away from the vein and a company man, usually one of the owners or a relative of an owner, with armed guards at his elbow, moves in to dig out the crystals. These are immediately put into a stout bag with a lock and carried to a safe place for later helicopter transfer to a special building in the heart of Bogata. This 15-story building is the heart of Colombia's emerald business, where emeralds are evaluated, faceted and made into jewelry.

In the huge open pit of the Tequendama Quarry at Muzo, the mountain is being benched as miners explore for calcite veins. Anywhere a calcite vein is cut open heavy equipment is used. Interestingly, the company man will never clean out the emerald pocket completely. He always leaves some of the smaller crystals for the miners, who collect them as their pay.

The largest slab of red beryl crystals found during mining in the Wah Wah Mountains holds over 100 crystals.

In the old days, when miners collected their crystal pay, they had to go to Bogata to sell their crystals. This caused all sorts of problems, from fraud to theft to murder for the gems. So the company arranged, once a month, for all the emerald buyers to come to Muzo and enter the mine property. The miners with their goods and the buyers with their money assembled on the dirt soccer field. It was interesting to watch the deals go down—or not. At least everyone was still alive when the event was over.

Emeralds have been the province of royalty until the last couple of centuries. Their vibrant green color, due to the transition metal ion chromium +3, gave them special significance to kings and queens. Vanadium, as a trace element, can also cause the green seen in emeralds, but this is uncommon.

When the Spaniards invaded what we call the New World, they were after gold, but by 1537 they were also gathering emeralds from the local royalty. When a Spaniard named Quesada invaded the region of Colombia, he was given gorgeous gem emeralds that had come from the Cordillera Oriental Mountain region. Try as they might, however, the Spaniards could not find the source of these magical stones. Fierce battles between the Spaniards and the local Muzo tribes ensued, and the Muzos won every battle, keeping the Spaniards from penetrating the mine area. It was not until the Spaniards brought in packs of fierce hunting dogs that they finally were able to defeat the Muzo tribes. Still, they could not find the source of emeralds, nor would the natives give up the secret.

The source of Colombian emeralds was found accidentally. A soldier's horse came up lame because of a rock in its hoof. The rock turned out to be an emerald crystal. The horse had been walking over the old jungle-covered dumps left from earlier Muzo Indian mining.

The way Colombian emeralds form is entirely different from those found in metamorphic schists, the more common source of emeralds. You might even say there is a Yin-Yang contrast here, since almost all other emerald sources produce crystals that occur in mica schist, chlorite schist, or other metamorphic schist. The resulting crystals are largely nongemmy, as the schist material is often included. Colombia, on the other hand, not only produces emeralds from a carbonaceous limestone and shale, but the crystals are largely water clear with gem potential exponentially higher than crystals from schists. The Colombian stones do have inclusions, usually typical two- and three-phase inclusions that do not affect their value, and in fact, sometimes serve as a means of distinguishing natural crystals from synthetics.

How the emeralds developed in the Colombian deposits has been carefully studied, and another Yin-Yang contrast has emerged. Unlike the red beryls of the Wah Wah Mountains, which form from a vapor phase, Colombian emeralds formed when hydrothermal solutions invaded ancient carbonaceous limestone and shales, leaching the beryllium and the metal elements chromium and vanadium, which give emeralds their color, from those host rocks. The green beryl crystals developed in calcite veins in the shales.

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The Yin-Yang of Beryl *from page 16*

The red beryls, as you recall, formed in the host rhyolite and in clay veins. The Colombian crystals do not usually have serious inclusions that despoil the crystals. Most are gem quality and grow to generous sizes that can yield faceted gems weighing several hundred carats.

I visited mines at Muzo and Cosquez. Just getting there was an adventure: We had to fly to Bogata, then take a small plane to Quipama, a small landing strip near Muzo. A young girl on the ground used a walkie-talkie to advise the pilot when the wild pigs were off the field and it was safe to land.

After having gone underground in six different mines at Muzo and Cosquez, the lasting impression I have is of being in tunnels where the temperature was in the 90s, with matching humidity. There was no drainage, so water stood at least ankle deep. No matter how you resisted, the filthy black carbonaceous shale invaded your body, clothes and equipment. When I finally left the mine area a week later, I left all the clothes I had been wearing underground, including my boots. They were beyond redemption.

There were guns everywhere at these mines, even underground. I saw more guns than mining picks. What I saw underground was worth all the discomfort and danger encountered. I saw stunningly beautiful green bolts jutting from the snow-white calcite veins.

To get to the operating face and possible crystals in one mine, I had to climb down a ladder made of metal pipe, wet and slippery, but sturdy. A hundred meters later, I stepped into a black, filthy tunnel with water halfway to my knees. The tunnel was low so you had to walk bent over. Several hundred meters down the tunnel, miners, wearing only loincloths and glistening with sweat, worked a soft calcite vein about 3 feet wide. The miners drilled holes to gave leverage to steel bars that could break out the calcite and, hopefully, expose green crystals. While I was there, no green bolts showed through. There was nothing to indicate that somewhere in that white calcite there might be gems worth tens of thousands of dollars.

At another mine, the superintendent was our escort. We walked some distance down a tunnel before coming to a door made of steel bars, just like a jail door. The superintendent let us in. A few meters along, we came to a lone miner, the superintendent's cousin, working a calcite vein with a rock pick. Sticking out of the vein were a half-dozen bright-green, completely clean hexagonal emeralds. I tried to get a close-up shot of the emeralds in place, but the super would not let me get closer than 3 feet. Then he took the rock pick, carefully removed all the crystals, and put them in his pocket. When we got back to the surface, he held out those crystals so I could get a picture. When asked their value, he suggested they would be worth about $50,000 in Bogata!

Though emeralds are found in several other countries including Zimbabwe, India, South Africa and Australia, the gems from Colombia are still the world's finest. But one American area matches the Colombian gems—in quality, but not in volume of production. In the Hiddenite region of North Carolina are pegmatite veins that have produced rare green spodumene, which we call hiddenite. On very rare occasion, a superb emerald crystal also comes to light.

Hiddenite native Jim Hill has had impressive good luck finding emerald-bearing pockets. In 1999, he struck a superb pair of crystals, one of which cut into an elegant 88 carat gem. More recently, he opened another pocket that extends at least 12 feet into the earth. Emeralds were in evidence, along with typical pegmatite minerals mica, feldspar and quartz. The North Carolina emeralds occur so sparingly and mining is so sporadic that what is found gets special attention, usually ending up in a museum or as a large faceted stone. North Carolina will never cause more than a ripple in the emerald gem market.

On the other hand, Colombian mines will continue to produce for decades to come, with more mines being found annually. It has been estimated that the undeveloped regions here hold at least 500 years' worth of production at the current rate of mining. Talk about Yin-Yang opposites; Colombia and North Carolina certainly fit!

While the collecting trip to the red beryl mine only produced a few small, but very nice, crystals, I consider it a rousing success. As luck would have it, shortly after our visit the boys began hitting some 2-inch crystals with lots of gem areas. No matter. One of these days, we'll go back and try our luck again.

The hospitality shown me by Clay Holman and the mine owners exceeded any gem we might have found. Together, they clearly fit the positive Yang of the mineral community, which has its share of negative Yin. It is also my understanding that the mine is for sale, as is that huge, beryl-laden rock described above. Collecting is not allowed, but anyone who might be seriously interested in buying the property can contact Clay Holman by calling (435) 864-3691. My thanks to Clay, Marlow and Earl for a great visit to a very interesting and obviously productive red beryl deposit.

SHOP TALK

by William A. Kappele

The Internet

At first glance, it may be hard to understand just how the Internet can be of help to lapidaries or jewelry makers. After all, you can't saw a slab with your hard drive, cut a cab with your CD-Rom, or cast a ring with your keyboard. And just try tumbling some Apache tears with your monitor. But just suppose that you are a beginner and you want to learn how a slab is cut from rough rock. You merely have to go to www.union.edu/PUBLIC/GEODEPT/hollocher/saws/ to access the site of Union College, an independent liberal arts college in upstate New York, founded in 1795 and chartered by the Board of Regents of the State of New York. At the site, you will find excellent close-up pictures and clear text on the use of both slab and trim saws.

Now that you know how a slab is cut, the next logical step would be to see how it is turned into a cabochon. Type in www.rockhounds.com/rockshop/oplc_cab.html and you will be at Bob's Rock Shop and Cabochon Making 101, with step-by-step text and photos that will show you just how a cabochon comes into being.

Are you an old-timer at cab cutting who has always thought about faceting, but didn't know where to find out about it? No problem. Just go to www.gemcutter.com/getstart.htm for a very comprehensive introduction to this fascinating aspect of the gemstone hobby.

A great site for general information about both lapidary and jewelry making can be found at www.gemsociety.org/info/info.htm. Here, you will find such things as reference charts for birthstones, weights and measures, the Mohs Scale of Hardness, lap materials, grit sizes, and much more. There is a section on the fundamentals of lapidary, including an introduction, and information on making smaller pieces, tumbling, cabochon cutting, and faceting. The list goes on and on.

You might be one of those who would like to build their own machinery. If so, try www.tomaszewski.net/Kreigh/Kreigh.shtml. You will find instructions on how to make a simple sphere machine, a classic rock tumbler, an open-top tumbler, a rock saw, and a horizontal lap.

Maybe you would just like to know where you can go to find rocks and minerals. Going to www.alibris.com/search/search.cfm will take you to a very large search engine for used books. For new books, try www.amazon.com or www.barnesandnoble.com. Just type in the name of the book, the author, or the subject, and away you go to more rockhounding books than you wanted to know about. More specifically, www.stonetrails.com/ORlocs/ORlocs.htm will take you to a list of rockhound sites in Oregon, with descriptions of the material to be found, maps to the sites, and driving directions. There are even safety tips and lots of miscellaneous information. The site www.stonetrails.com/WAlocs/WAlocs.htm will give you the same kind of information about Washington state. For another specific area, just type the name in your search engine and hit Enter. Glass Buttes, a famous area in Oregon for obsidian, is a good example. You will find page after page of references, maps, rockhound information, and scientific data on obsidian.

Be aware that Web sites are not static; information can come and go, and a page that appeared yesterday may not appear today. Also, server problems can randomly block access to sites. Persistence sometimes pays off; keep entering the address until it works.

This barely scratches the surface of what you can find on the Internet. You owe it to yourself to give it a try. If you don't happen to have a computer, or if you are not hooked up to the Internet, try your local library. They probably have one available, and you can use it to find out just what you have been missing.

Please feel free to contact me if you have a suggestion or comment about this or any of my Shop Talk columns. My e-mail is quappelle@cox.net, or write to me at 25231 Pericia Dr., Mission Viejo, CA 92691.

THE FRUGAL COLLECTOR

THE OXIDES

PART III:

Is Quartz an Oxide or a Silicate?

by Bob Jones

One of the major controversies for decades in the field of mineralogy had to do with deciding whether quartz was an oxide or a silicate. After all, it is a single atom of silicon joined with two atoms of oxygen. Surely it's an oxide. But, because of its composition, it seemed silly not to include the purest form of a silicate with minerals containing the silicate SiO_2. It fit the definition of a silicate, so why not include it in that chemical family? After much discussion we now know that most texts and scientists classify quartz as a silicate.

Another compound we are familiar with is water. It, too, consists of one element attached to oxygen, so technically, it is an oxide. But there is cause for disagreement. When written as two hydrogens and one oxygen, it is clearly an oxide. But, when written as one hydrogen attached to the hydroxide radical OH, you get a different picture—a hydroxide rather than oxide. This is rather a moot point, since hydroxides are usually grouped in textbooks as part of the oxide family.

In Part I of the oxide series, I described a number of manganese oxides, but did not include the classic manganese oxide manganite. The classic specimens for manganite are from Ilfeld in Germany's Harz Mountains. The deposit is no longer worked, but huge quantities of manganite was forthcoming years ago. The crystals are deeply striated and lustrous black, sometimes with white barite or calcite. The terminations look pitted. Lustrous clusters of 1- and 2-inch crystals, because of their historical value, are quickly swept up by collectors, even though they command fairly high prices.

Here in the United States, the best manganites came from Marquette and Negaumee, Michigan. Masses of crystals, tightly clustered so that they form solid botryoidal masses with bright, squareish crystal terminations, were fairly common there at one time. The best may well have come from the Jackson Mine.

Currently, the best manganite and related minerals come from the Black Rock District of Kuruman in Cape Province, South Africa. This is the source of some spectacular rhodochrosites, often found on a black manganese matrix, which sets them off beautifully. These mines are also the source for sturmannite, a yellow hexagonal crystal found in some abundance. Two other Black Rock minerals of note that form abundant excellent display crystals are lovely yellow ettringite and spectacular orange-red inesite. Never seen in large crystals, inesite occurs as small scalenohedrons or needle crystals covering the matrix in profusion.

For the lapidary, the Black Rock District has produced marvelous violet to blue sugilite, along with lovely red to mahogany bustamite and rhodonite, almost indistinguishable from each other. The variety of colorful, massive manganese minerals includes good cutting minerals like tephroite.

Excellent Black Rock specimens of lustrous black manganese oxide form in botryoidal masses with sparkling surfaces. The best form the matrix for brilliant red rhodochrosite crystals, a stunning contrast of red on black. This entire manganese area, the richest in the world, will be addressed in a separate article in *Rock & Gem*.

In my opinion, the most exciting mineral to be described in this article is chrysoberyl. This gorgeous, gemmy yellow-green mineral comes in a variety of twinned crystal forms more often than in single orthorhombic crystals. Chrysoberyl is largely a pegmatite mineral, so you can expect it to come largely from Brazil. However, the first chrysoberyl ever found and identified was actually found while digging a water well in Haddam, Connecticut. The area around Haddam, in the middle of the state, is one of America's earliest investigated pegmatite regions. The Strickland and Gillette quarries were prolific producers of fine tourmaline, beryl, and some of the less common pegmatite minerals. The chrysoberyl found here was pale yellow, a small V twin showing striations and about ½ inch long. The specimen is in the Amherst collection. Other New England pegmatites, particularly Topsham and Paris, Maine, have produced chrysoberyl in past decades, but those mines are not active any more.

Brazil produces the world's finest chrysoberyls in quantity. Fine chrysoberyls are occasionally found during gem mining at Bahia at Campo Formosa and Teixeira de Fritas. The state of Minas Gerais, which is really Brazil's jewel box, boasts a number of chrysoberyl sources. The best known source is Espirito Santos, which produced superb yellow to yellow-brown

Stibiconites from Mexico are actually pseudomorphs of stibnite and retain the long, tapered, bladelike crystal shape (Evan Jones collection). (Photos by the author)

gems. Some of the specimens are tabular, but the majority showed some of the finest V and heart-shaped twins of paired chrysoberyl crystals. More desirable are the pseudohexagonal specimens, which tend to be rather flat and consist of three pairs of geniculated twins, all joined to form a perfect six-sided cluster. These are particularly popular with collectors. Most show three deep reentrant angles as the paired crystals join to form the disc. Penetration twins and contact twins are also common here.

Other Brazilian sources include Teofilio Otoni and Colatina, but these are not as well known for chrysoberyl as Espirito Santos.

A lot of the faceted and cabochon-cut chrysoberyls you see for sale are from Sri Lanka, where descrete crystals are not found. Instead, rounded pebbles of the yellow to yellow-green and brown crystals are found in stream gravels along with other important gem rough. These rounded pebbles are frequently cut en cabochon and oriented to show a wonderful cat's-eye streak due to the inclusions of needlelike crystals or thin, hollow tubes in the gem. The finer cat's-eyes are yellow or green with a brilliant white streak of light running right over the high dome of the cab. Most of these gems also show chatoyancy, an inner glow of light due to the scattering of ambient light. The chatoyant or even opalescent gems were called cymophane early on, and that name persists today.

Exciting as chrysoberyl cat's-eyes are, the variety that stirs some emotions even today is alexandrite. This historically important and most unusual variety of chrysoberyl has the unusual property of showing two distinctly different colors under two different light sources. When seen under ordinary daylight, the gem is a lovely green. Under ordinary household tungsten light, it is a fine red. The classic alexandrite comes from the Takowaya River, near Sverlovsk (formerly Ekaterinberg) in the Ural Mountains of Russia. Sri Lanka and Espirito Santos, Brazil, have produced some alexandrites, but Russia is the primary source of this gem. Keep in mind that the abundance of alexandrite now available on the market is synthetic. Russia produces most of it and leads the world in synthetic gem creation and production.

A large ruby (aluminum oxide) crystal embedded in zoisite is very popular with gem carvers (Kristalle specimen).

Brazil produces the world's finest chrysoberyl (beryllium aluminum oxide) in quantity (Smithsonian specimen).

The late John Sinkankas executed this painting of a franklinite and pink rhodonite specimen from the Evan Jones collection.

Once alexandrite was found in Russia, there was a rush to dig crystals and a small cluster of mines called the Izamorudnye mines developed. Here the crystals are found locked in sparkling, grayish mica schist. The largest known crystal is displayed at the Fersman Museum in Gorky Park, Moscow, and is a cyclical sixling measuring 2 inches across. The crystal has been removed from its enclosing matrix. It is not gemmy, has mica embedded in its faces, and has a rather dull grayish-green color, but it is a remarkable example of this unusual gem.

The same museum also boasts one of the world's finest alexandrite crystal groups, a micaceous mass about 8 inches across with some 22 crystals embedded in it. The mica has been worked away to expose the crystals. The largest crystal in the specimen is almost 2 inches across!

The discovery and naming of alexandrite is an interesting story. The first crystals were found in 1830 in the same area as Russian emeralds, which also occur in the greasy, gray mica schist. Miners realized the crystals were something different, so the gems were taken to the lapidary factory at Ekaterinberg, where the czars employed craftsmen to create works of stone art for their palaces. The head of the factory had the unusual crystals tested. The tests proved they were chrysoberyl, but a most unusual variety, deserving of a new name. Because the first crystals were found on the birthday of Czar Alexander II, the obvious way to win favor with the czar was to name the mineral after him!

You may wonder how one crystal could show two different colors in two different lights. Actually, this is not a rare phenomenon in minerals. Specimens can often show different colors under longwave and shortwave ultraviolet light. The calcites from Terlingua, Texas, for example, show blue under longwave and pink under shortwave.

To understand the alexandrite phenomenon, you have to realize that all light energy is not the same. Light from two different sources has a different mix of color wavelengths. What gives any gem its color is the absorption of certain wavelengths of light as it penetrates the gem. Internally, the gem's chemical makeup absorbs a selection of those wavelengths and emits the rest. You see these emitted wavelengths of light as color.

continued on next page

In order for a gem to show color, something has to be going on internally. Most gems have trace impurities like chromium, vanadium, or other transition metal elements that selectively absorb some light waves. In ruby, for example, the impurity chromium absorbs all except the longwave energy, so you see red. Chromium also occurs in emerald in trace amounts, but this time it absorbs everything but the green wavelengths of light because the internal atomic structure in emerald differs from that of ruby.

In alexandrite, chromium is the color activator. Under natural light, which is largely a balance of all color wavelengths of light energy, the chromium atoms absorb most of the light, but not the green wavelengths, so the gem appears green. Tungsten light is not a balanced assortment of wavelengths of energy. It tends to have a lot of yellow in it. That's the reason your indoor photos tend to come out yellow! Similarly, when you look at alexandrite under tungsten light, the chromium absorbs a different assortment of light energies and the mineral looks red.

Getting away from costly gemstones, there is a pair of very attractive, black, shiny titanium oxides, anatase and brookite. They are not common, though specimens do show up occasionally, usually from old collections. Along with rutile, described in Part II, anatase and brookite form what is called a trimorphous group; they are closely related chemically and can form pseudomorphs of each other. In this country, the best known rutile/brookite pseudos came from Magnet Cove, Arkansas. The lovely samples of brookite, showing distinct striations and in the typical geniculated form, have been replaced by rutile and are highly prized. Magnet Cove also produced single tabular brookite crystals in ugly gray quartz.

Wonderfully sharp, lustrous brookites from the metamorphic schists of the Swiss mountains have long been sought. These fine crystals occur in small pockets in alpine veins. Alpine veins that produce brookites occur in Russia and Italy, as well. Brookite is usually found associated with quartz, rutile and fluorite. Good specimens are very difficult to obtain, so keep on eye out for these.

Anatase, the tetragonal member of this threesome, is best seen as acute dipyramidal crystals perched on colorless to smoky quartz crystals from Norway. A spate of these specimens hit the specimen markets a couple decades ago and were instantly popular. Exceedingly sharp, brilliant black, and scattered along the prism faces of the quartz, these were quite attractive specimens. Once in a while, one of these specimens shows up for sale, and lucky is the collector who stumbles upon one.

The famous Ojuela Mine at Mapimi in Durango, Mexico, has yielded a great variety of minerals in untold volumes. It's famous for adamite, legrandite, hemimorphite, wulfenite, mimetite, and other colorful species. But not much attention has been paid to the small, black crystals that were often found generously sprinkled over the matrix along with these more colorful, larger crystal species. These are bright black plattnerites, lead copper oxides that form due to weathering in ore deposits in the desert. Any noteworthy mine in any desert region—Mexico, the American Southwest, Iran, North Africa, Tsumeb, Namibia, or New Mexico—and even nondesert areas—like Coeur d'Alene, Idaho, and Scotland—have produced both crystallized and massive plattnerite in quantity. The crystals are always tiny, usually micros, but in tight clusters that can cover a specimen. Plattnerite is associated with the usual laundry list of secondary lead and copper minerals like smithsonite, cerussite, hemimorphite, hydrozincite, aurichalcite, murdochite (with which it is easily confused), wulfenite, and pyromorphite.

At the Ojuela Mine, plattnerite was often found as small black crystals scattered over the matrix, with white needle crystals of hydrozincite heavily encrusting the matrix. The hydrozincite fluoresces a lovely soft blue under shortwave ultraviolet.

Another oxide from Mexico is stibiconite. Stibiconite crystals look like pale tan, yellow-brown, and almost orange stubbies. That's because they are actually pseudomorphs of that antimony sulfide. Good stibiconites completely mimic the long, tapered, bladelike stibnite crystals, even preserving the deep striations common to the sulfide. The Mexican stibiconites came from Catorce, San Luis Potosi, some years ago and are almost never seen on the market today.

However, China has come to the fore with large clusters of stibiconite crystals that can be 6 or 7 inches long and in crystal sprays a foot or more across. Most of the Chinese stibiconites show some damage, as the mineral is really brittle, and early efforts to collect this mineral in China were haphazard at best. Things have now improved, so the quality of the Chinese stibiconites has improved.

There are a number of radioactive oxide minerals. The primary uranium mineral, uraninite, is uranium oxide with one atom of uranium attached to a pair of oxygen atoms. When this mineral breaks down, it produces a wide array of radioactive minerals, all very colorful and attractive but, like the parent mineral, lethal in the long term.

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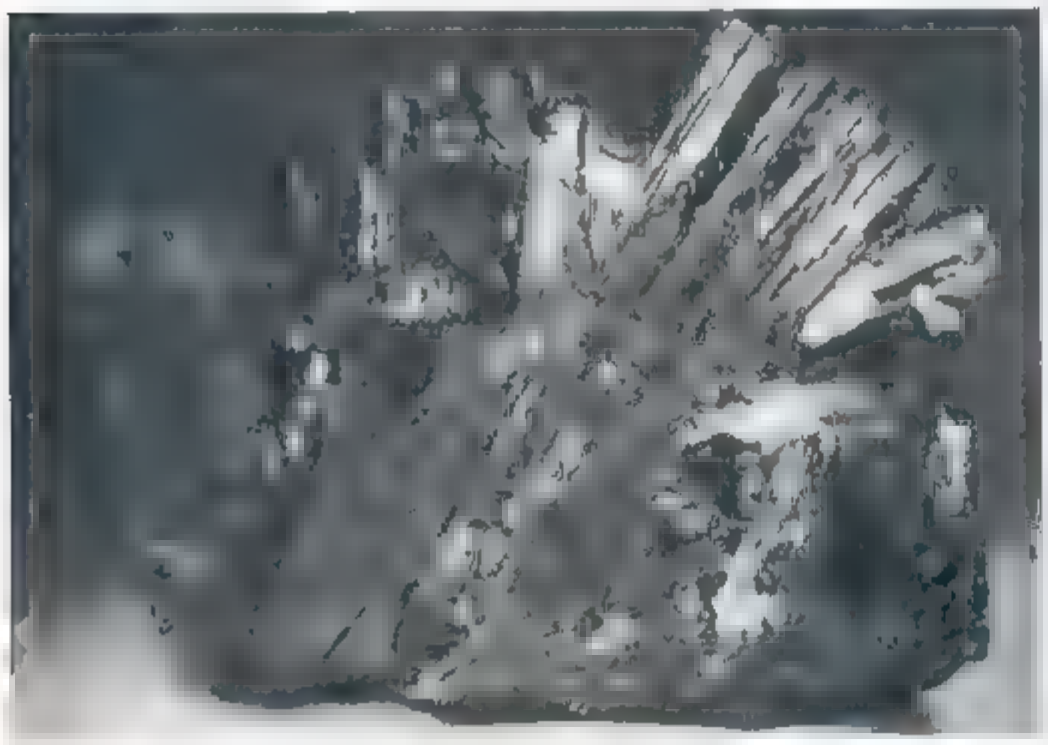
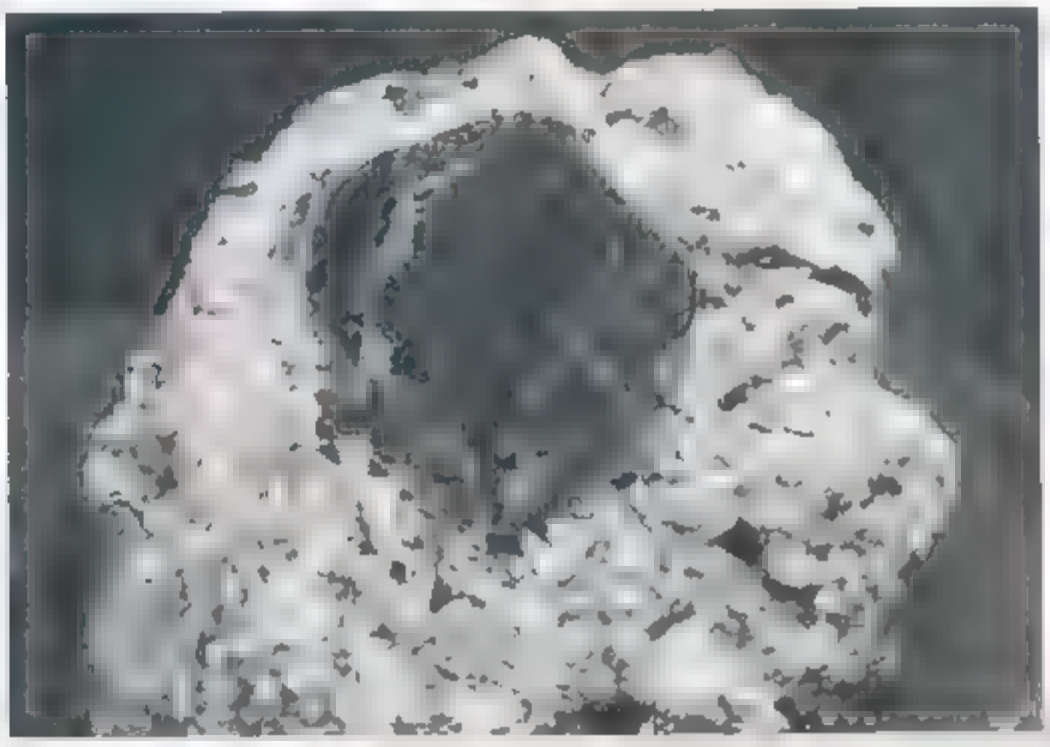


The classic specimens of the manganese oxide manganite came from Ilfeld in Germany's Harz Mountains (Kristalle specimen).



Rutile, described in Part II, forms a trimorphous group with anatase and brookite. This Graves Mountain, Georgia, specimen is owned by Kristalle.

The Oxides *from page 22*

At the end of World War II, I was serving in the 509th Composite group, the fleet of B-29s that did the atomic bomb testing in the Pacific. We didn't think much about radioactivity in those days. I was only 20 miles away in a B-29 photo plane when one blast went off. Wearing goggles like those used by welders, I was able to read my instruments when the blast flash occurred. Our only recognition of radioactivity was the film patch we wore and the fact that we had to shed our clothes when we returned to Kwajalein and take a shower. I guess it worked, because I'm still here! We had a rather casual attitude toward radioactivity, one which I must admit I still have.

After the war, when I specialized in fluorescent minerals, I often collected all sorts of secondary radioactive uranium minerals, many of them oxides of uranium, vanadium and the like. They included fourmarierite, schoepite, curite, kasolite, autunite, becquerelite, dewindtite, phosphuranylite, meta-autunite and torbernite.

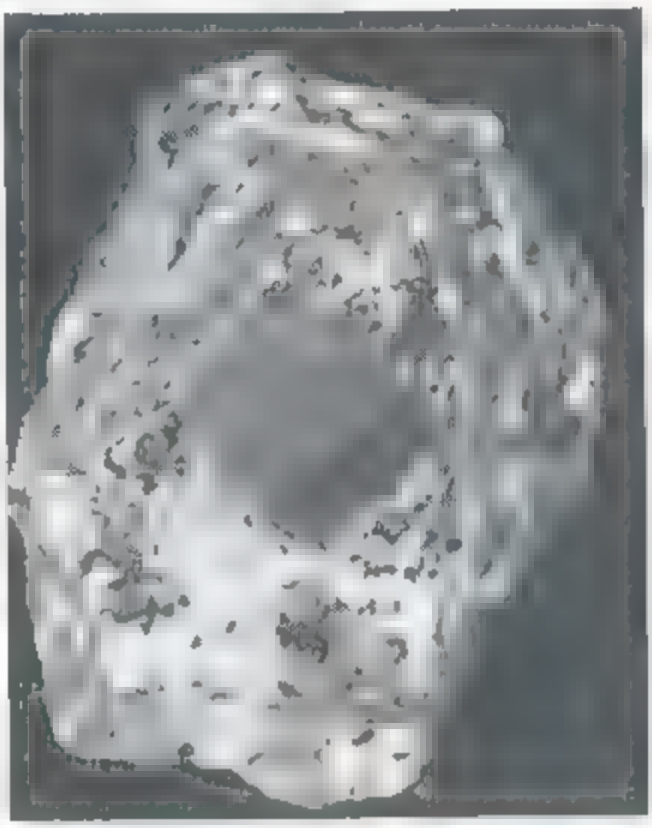
One of America's best sources of one radioactive mineral was the Daybreak Mine at Mount Spokane, Washington. This mine produced amazing tight clusters of bright-green bladed, brilliantly fluorescent crystals of strontian meta-autunite in quantity. These specimens gradually lost water and broke down, with the individual blades splitting away and eventually coming completely apart.

The meta-autunite blades were interesting in that they were a wonderful yellow to lime green along the edges, but toward the base of each blade, the color gradually changed as black dots and finally black streaks of an included mineral were seen. This black zoning in the micaceous crystals was actually microscopic, and granular uraninite enclosed in the secondary mineral. We paid little attention to the problems of radioactivity and radon in those early days, so such species were easily obtained.

The Four Corners area of Arizona, New Mexico, Utah, and Colorado is riddled with uranium mines and dumps that yielded plenty of specimens. The states are rapidly sealing off these mines to prevent weekend explorers from entering and breathing the heavy, radioactive radon gas that accumulates in the mines. I wore a special breathing mask when I collected bobjonesite from the North Mesa #5 uranium mine in the San Rafael wash area of Utah. The mine that produced bobjonesite has since been sealed shut.

These days, I don't get too excited about such things as radon and radioactivity. Using common sense, I don't keep radioactive minerals under my pillow, and I'm not too far off my 80th birthday. Still, I've been lucky that radiation hasn't seemed to affect me. Because of the taboos placed on radioactivity these days, mineral dealers don't carry quantities of these minerals. You can still collect fine uraninite cubes in Canada, and the occasional cube shows up in a pegmatite, the best being some of the mines in Maine. Because of the inherent dangers of radioactive minerals, collecting such oxides would seem a bit foolish!

One of the oxides I became very familiar with in the early days of my collecting was franklinite. Because of my interest in fluorescent minerals, I spent a lot of time in Franklin and Sterling Hill, New Jersey, home of the world's greatest variety of fluorescent minerals. Many of these minerals are associated with franklinite, which is not fluorescent.



Superb cubic crystals of uraninite (uranium oxide) occur at Witherforce, Ontario, associated with feldspar and fluorite.

Franklinite is a zinc, manganese, iron oxide that is more complex than its name implies. It seems the manganese and the iron in its compound each come in two different valence forms: manganese, valence two and three, and iron, valence two and three. It is almost always found as octahedral crystals. Fine, sharp crystals are not common there, though franklinite was one of the main ores from these complex ore bodies. It can be lustrous to dull, and in the Franklin area can often be found as completely rounded grains intimately mixed with zincite, calcite and willemite.

These Sussex County ore deposits are quite unusual. They have yielded well over 300 different mineral species, over 25 of which respond to ultraviolet light. The deposits are ancient, they formed as high-temperature metamorphic deposits from marine carbonate sediments that were intruded by what we think were black smokers, those ocean floor surging hot springs we see today along crustal plate boundaries.

The franklinite crystals from these ancient zinc deposits are the world's finest. They can be several inches on an edge, but are usually under an inch on an edge. They are almost always completely enclosed in the white metamorphic limestone and, because they are brittle, damage easily. When you look for franklinite crystals, watch for repairs made to hide natural or inflicted damage. Miners, knowing the value of complete franklinite crystals, often filled in the broken edges with plaster of Paris or similar material, then stained or painted it black.

This sharp inch-long crystal from Norway is an excellent specimen of the rare titanium oxide anatase.

Franklin (named for Benjamin Franklin) and Sterling Hill (named for Lord Sterling, an early mine promoter) are the most significant sources of this black octahedral oxide. Since all mining at these localities has ceased save for small efforts at Sterling Hill by the Sterling Hill Mining Museum staff, you might think little franklinite is available today. That isn't entirely true, since huge quantities of this zinc mineral were salvaged during mining and are sometimes seen for sale even now, 50 years after the last mine closed here.

The Sterling Hill Mining Museum also brings ore from underground, piles it on the surface, and offers free collecting to rockhounds. The owners of the mine museum recognize the plight of all rockhounds as locality after locality closes, so they make special efforts to give collectors some experience collecting Sterling Hill mine material. During the annual Franklin, Sterling Hill Gem & Mineral Show, collecting trips are taken to any one of several dumps that still yield the occasional mineral treasure. Join the fun as museum member by writing to the Sterling Hill Mining Museum, 30 Plant St., Ogdensburg, NJ 07439. Graduated memberships range from $15 to $.00 per year. One special member opportunity is free collecting on the mine run dump, including night collecting, when you can use your ultraviolet lamp to great advantage!

A second source of franklinite is Langban, Sweden, an ore deposit that is in some ways much like Franklin, some of the same fluorescent minerals were found there along with franklinite. Unfortunately, Langban has been dormant for years.

Another oxide that is common at Franklin and Sterling Hill is zincite, a simple zinc oxide. You'll never see natural crystals of zincite for sale, as only a handful of any quality exist. But, you say, I see bright, lustrous clusters of bright-yellow to greenish and even bright-red zincite crystals for sale at almost every show. True, but they are not natural crystal groups.

When zinc minerals are smelted, the zinc fumes escape into the furnace flume and combine with available oxygen, forming layers of transparent, waxy, colorless, yellow, orange, or red crystals on the inner walls of the furnace. They are very gemmy and lustrous and fluoresce beautifully, but they are man made. There's nothing wrong with such specimens, as long as you realize they are not natural. The material is so gemmy it can be faceted into vibrantly brilliant gems, but with a hardness of about Mohs 4 to 4.5, they are barely suitable for jewelry.

Natural zincite is found in relative abundance at Franklin and Sterling Hill. It occurs as brick red seams, layers, masses, and occasionally rounded grains. It actually constituted about 1 percent of the zinc ore mined there. The material can be cut and polished into interesting, colorful slabs, but again, hardness is minimal. With such a mix of minerals, the lapidary has to watch for undercutting and variations in polishing.

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An oxide mineral sometimes confused with franklinite is gahnite, or zinc aluminum oxide, a much simpler chemical compound. It occurs in octahedral form, is a very dark greenish black and can occur in high grade metamorphic deposits. In Franklin, it has been found in fine crystals. It also occurs in granite pegmatites and has been reported in Madagascar, Brazil, New South Wales, Australia, and Quebec, Canada. Some of the better crystals were found at Falun, Sweden, another long since closed source.

One of the more common black oxides is the calcium titanium oxide perovskite, which occurs in alkaline mafic rocks and nepheline syenites. It is much more common and available than franklinite or gahnite because it is being found in quantity in several of the recently opened Russian specimen sources. Superb large crystals were found in the Ural Mountains and, even more recently, on the Kola Peninsula. Localities in Germany and Italy have been the more traditional sources of this black to brown, sometimes even yellow, mineral.

The famous metamorphic limestone deposit at Crestmore, California, has produced a fascinating variety of species including perovskite. Crestmore started out as a small mountain, but today is virtually an open pit, as mining for limestone cement has been going on there for decades. Collecting here used to be possible with guided groups, but not lately.

Another classic source for perovskite was the complex deposit at Magnet Cove, Arkansas. This classic produced wonderful rutile geniculated twins, superb pseudomorphs of brookite, and, of course, perovskite. Like most deposits, this one has been long since worked out and closed.

Another source for perovskite is located in San Benito County, California, bordering the more famous benitoite gem mine locality. These specimens find their way to the market, as collectors occasionally dig in the area. But like all black minerals, they are not often featured on dealers' shelves because of the mistaken belief that black minerals do not sell well.

Those who enjoy collecting their own minerals might find their way into the Thomas Range of Utah. Here you'll find an abundance of superb textbook crystals of topaz, colorless when found on the surface and sherry colored if dug out of the hard rhyolite. Associated with the topaz are two oxides, bixbyite and pseudobrookite.

Bixbyite occurs sparingly as small black cubes, often attached to the topaz crystals or lodged in the claylike lining of a gas cavity. The crystals are seldom more than ½ inch across; crystals of an inch on an edge are rarely found. The crystals are usually lustrous and sharp. When you tire of collecting in the Thomas Range, near Delta, drive over to the Dugway State Park, where digging geodes is allowed in an area set aside for rockhounds!

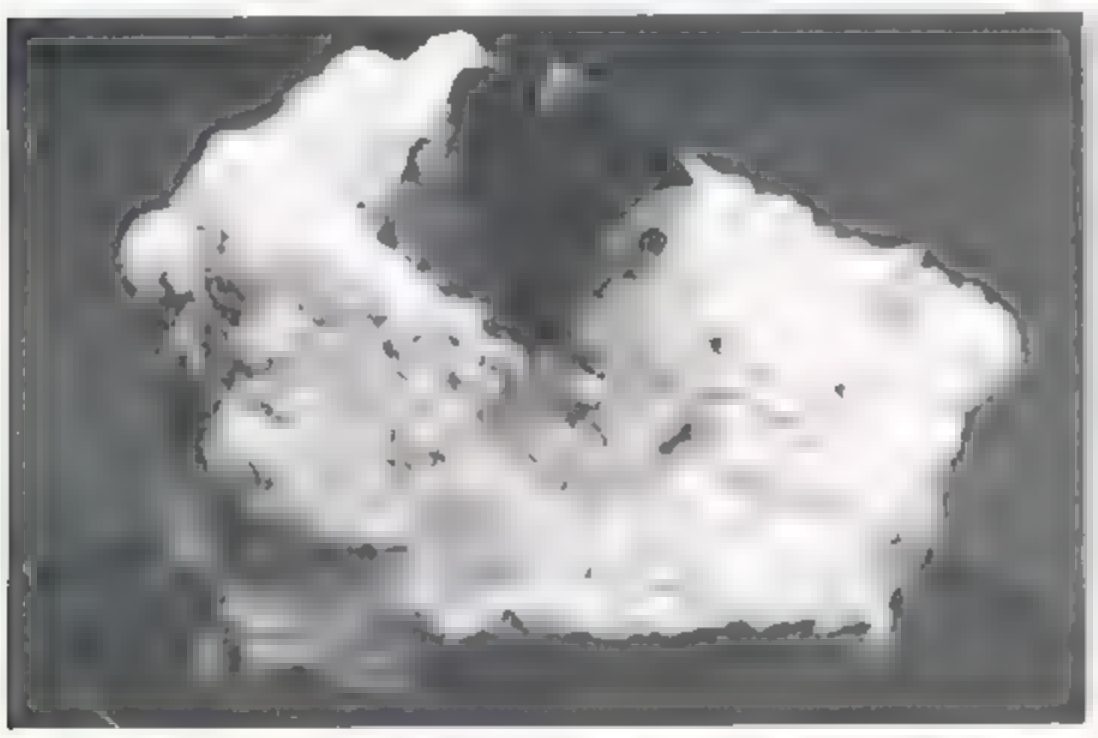
On a recent trip to the Wah Wah Mountains to dig red beryl, we had hopes of finding small bixbyites, since the rhyolite environment is very similar to the Thomas Range. All we found were tiny black grains in the gray white rhyolite. We didn't find any topaz, either, but we did find nice red beryls!

Much less commonly occurring with the topaz and bixbyite are slender, even needlelike blades of pseudobrookite that may reach an inch in length. Also black, these lathelike crystals are a real prize when you manage to dig them out. They are often found penetrating bixbyite crystals in the Thomas Range.

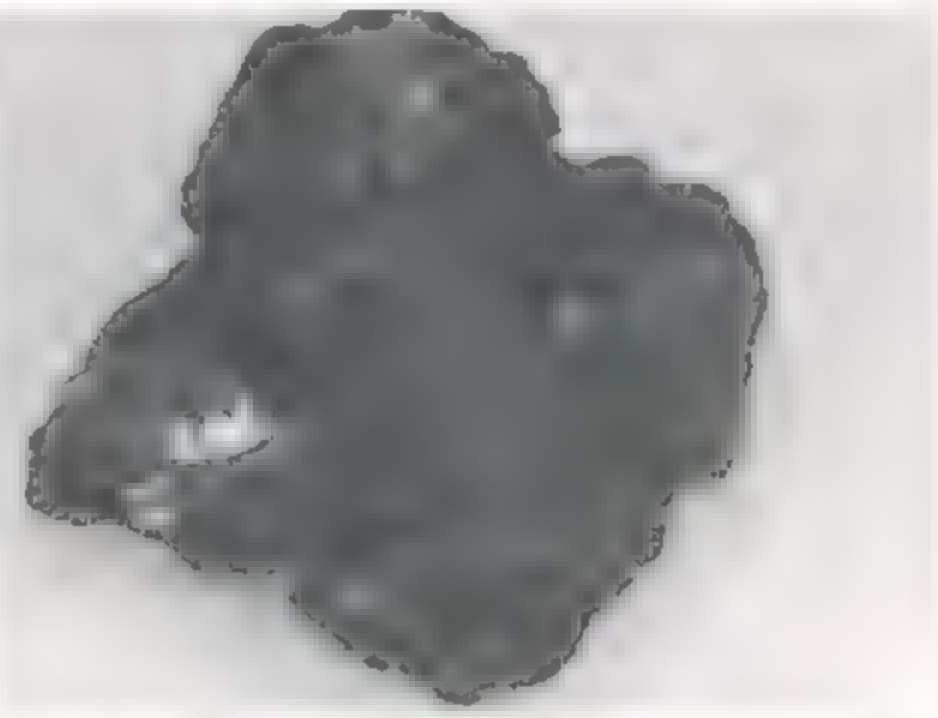
If you want a very unusual source for perovskite, check with meteorite dealers. A less common type of meteorite is called carbonaceous chondrites. These are an odd mix of nickel iron and stony material like peridotite, perovskite, and the like. So if you want a specimen of perovskite buy a slice of carbonaceous concrete, but be sure the dealer points out which of the glassy-looking blebs is perovskite.

One of the more confusing pairs of oxides is columbite-tantalite, so confusing, in fact, that they are not always listed as oxides but as tantalates or columbates. Sometimes, they are even left out of mineral listings. That's hard to imagine, since they do exist and are not exceptionally rare. Part of the confusion stems from the mineral columbite, which is composed of an element once called columbium and now known as niobium. Another reason for confusion is the intermixing of these two minerals so that you never quite know if you have one or the other. Added confusion comes from the terms ferrotantalite and ferrocolumbite, or manganoan columbite and manganoan tantalite. All these names are now invalid. Still, you'll find these lustrous, black, tabular minerals around if you look hard enough. Just enjoy the lovely striated crystal form of the columbite or tantalite or whatever it is labeled until scientists make sense out of this complicated group of species.

Because so many gems and minerals are oxides, the entire chemical category can be well represented in any mineral collection or collection of jewelry. There are certainly enough oxide minerals found in quantity: cuprite, hematite, the corundums, spinel, magnetite, cassiterite, rutile, the manganese oxides, and more, so you can enjoy a full range of oxides in your collection. And if you include quartz in your oxide group, you'll run out of shelf space before you run out of minerals to collect!



Bixbyite is an uncommon oxide species associated with topaz in Utah's Thomas Range.



Rutile after brookite in a cyclical twin crystal group from Magnet Cove, Arkansas, is a real oddity. (Evan Jones collection).

FIELD TRIP

Oklahoma AGATE

This piece of petrified wood has faint black growth rings. The white outer coloration is common in petrified wood on the mesa.

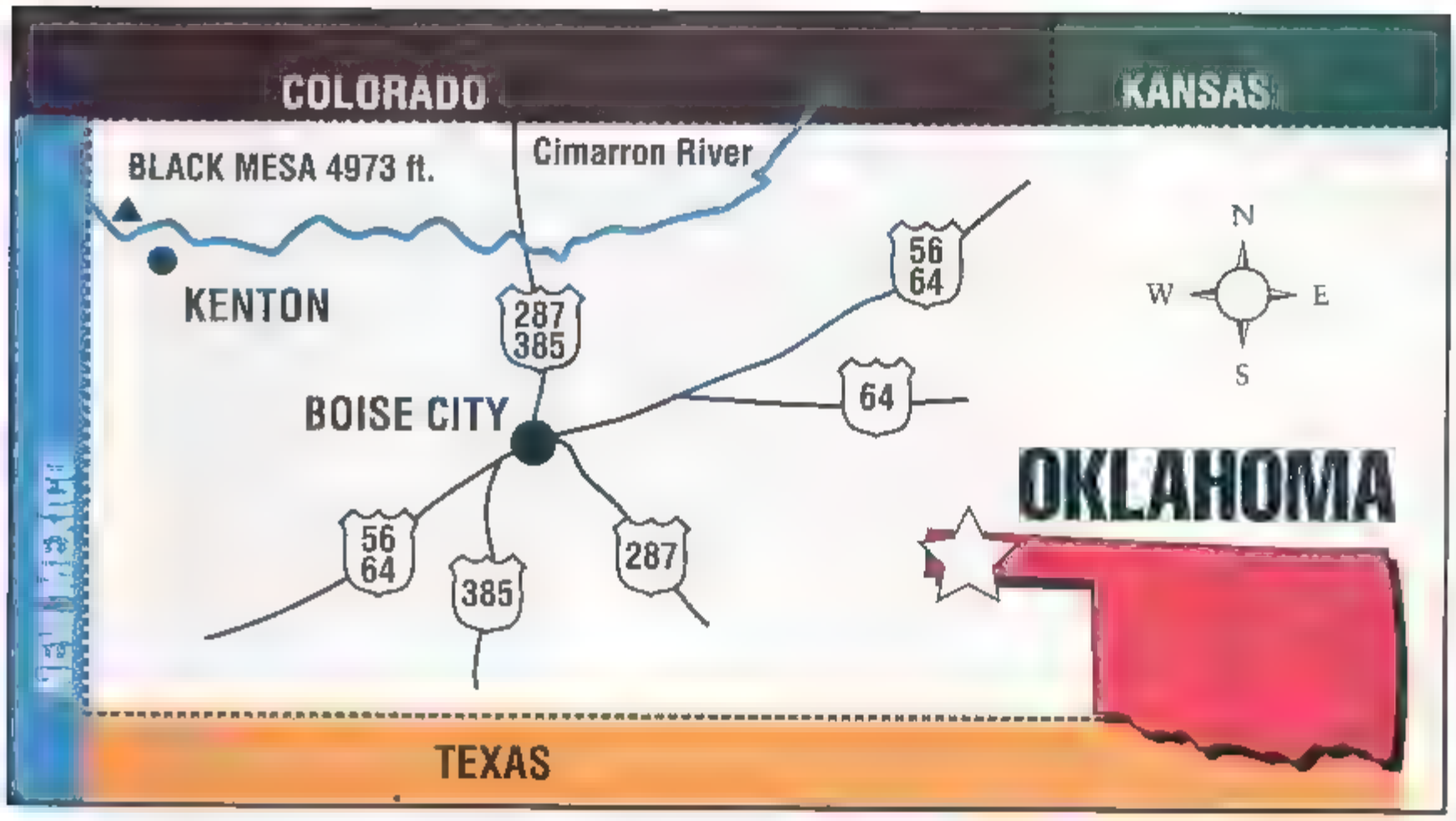
A window in a piece of rose agate found on a gravel bar along the Cimarron River reveals a blue core.

Fine examples of agatized wood can be found on the slopes and tops of mesas on the Roberts' Ranch property. (Photos by the author)

Collecting along the Cimarron River and Black Mesa Canyon

by Kenneth H. Rohn

Whenever I set out on a new adventure, there's always that exciting element of the unknown involved. Such was the case with this trip, as I entered Oklahoma from the northeast on U.S. Highway 56. I've learned through long experience that no matter how well one plans a trip, or how much research goes into it, only setting foot on the actual collecting site will tell me whether I made a good choice. The weather plays a large part in the overall event. Nothing can squelch a field trip more quickly than bad weather, be it wet and muddy, too scorching hot, or very cold. In other words, approaching a new and unproven collecting site is a gamble. But, I might add, a gamble well worth taking most of the time.



I was thinking about Black Mesa and what I might encounter in the far western reaches of the Oklahoma panhandle while en route to my destination, which is Roberts' Ranch, east of the town of Kenton. It was mid-February, and the ground was bare for the most part, with only a smattering of snow in the shaded areas. I was thankful for that. The tops of the mesas had substantially more snow, indicating colder temperatures in the higher elevations. Although the sun was shining brightly as I neared Kenton, the temperature hovered around 45 degrees – not what I would call ideal conditions for collecting, but tolerable.

From research, I learned that I might find a variety of collectibles at this private working ranch. Petrified and agatized wood could be found on the slopes and along the tops of mesas, plus fossilized algae, particularly along the Cimarron River bed and banks. The Cimarron River is a mere 200 yards, if that, from the ranch house. Rose agates and other types of agate and jasper can also be found on the property. If we're very lucky and search carefully, we might find petrified cycad stump sections. The cycad was an ancient plant that might be called a cross between a palm and a fern. It resembled a fern more than a tree, although it had palmlike leaves, or fronds. The actual trunk of this plant was made up of the stems growing together in one cohesive mass. When a cross section of this fossil stump is cut and polished, the beautiful diamond markings of those fronds are revealed. I was hoping to find at least one cycad fossil during this field trip. I did have the good fortune to discover cycad remains in northwestern Nebraska on another field trip a few years ago. It is a most interesting fossil.

The possibility of discovering various other fossilized life forms, shark teeth, and invertebrate fossils is good. I saw some excellent shark teeth at the ranch house. It's a strange phenomenon: Sharks do not have bones like normal vertebrates. Instead, their skeletal structure is composed of cartilage. Therefore, it is a very rare occasion when any part of the shark is found fossilized other than the teeth.

I was anxious to see what Black Mesa rose agates look like, as I had never seen any from this locality before. The petrified wood is scattered mostly along the slopes in the higher elevations of the mesas on the property. It tends to be several shades of brown. Some beautiful white petrified wood can also be found here, as I was to learn. If I were lucky enough to discover a fossil or two during my stay, it would be frosting on the cake. Of course, my main interest was rose agate and wood.

Kenton, Oklahoma, is a small, friendly community situated rather uniquely, only a short distance from several other states. As the crow flies, the New Mexico border is approximately five miles west, and it's only a little more than 10 miles north to the Colorado state line. Texas is about an hour's drive to the south, and Kansas, via state Route 325 and U.S. Highway 56, is another hour and a half away to the northeast. When people get together for a special occasion in Kenton, they can be from any of these states, and they usually are.

The main vocation in the Oklahoma panhandle is cattle ranching. Huge herds can be seen in this western extreme of the state, often referred to as "The Cherokee Strip." I encountered a large herd at Roberts' Ranch while driving on the 4X4 road adjacent to the Cimarron River. I was doing a bit of investigating before actually going out collecting. The cattle at once crowded around my pickup, thinking that my vehicle was the feed truck coming to give them their supper. I had to drive extremely slowly in order to get through the maze of critters. It doesn't take much to stampede cattle, and honking one's horn at them can cause havoc.

The Roberts' Ranch is a huge tract of land two miles east of Kenton on state Route 325. From the gate, it's another two miles via the ranch road to their headquarters. The ranch buildings themselves are situated in a beautiful, vast, rolling valley between high mesas. As a matter of fact, the highest point in Oklahoma, Black Mesa, is just a few miles northwest of Kenton at an elevation of 4,973 feet above sea level. Being a Midwesterner, I think a land holding is large if it is 40 acres or so. In the panhandle of Oklahoma, they count their land ownership in sections rather than acres.

I found the ranch entrance road rather unusual because of a secondary road that goes off on an angle to the northwest, parallel to state Route 325. It joins with state Route 325 to form a "Y" about 100 yards or so beyond the ranch road. If you make a wrong turn, make a U-turn off the main highway, drive a short distance, then turn right onto the ranch road. Watch for the Roberts' Ranch sign. It's a well-maintained gravel road, but not built for speed. You'll see other roads branching off, here and there. These are less traveled, showing signs of brush and grass growing in the ruts. Just stay on the well-traveled road to the inner gate and cattle guard.

When I rang the doorbell at the ranch house, Mrs. Diane Smith welcomed me. Since it was a bit early in the season, I told her why I was there. I wanted to do some high-quality rockhounding on their property, if it was permissible. She told me that it most certainly was, and explained that she and her husband, L.G., had only recently re-opened the collecting site to rockhounds. The business was started years ago by her parents, Mr. and Mrs. Roberts.

continued on next page

Oklahoma Agate *from page 29*

I saw some wonderful examples of those years of collecting at the ranch headquarters. The circular driveway is lined with the most magnificent display of petrified logs set in a vertical position forming a rock fence. Some of those log sections, I would imagine, weigh several hundred pounds and were carried from the mesas by heavy equipment to their final resting place in Smith's Door Yard. Ask the Smiths if they'll show you their fireplace. It will take your breath away, believe me. It's a wonderful display of craftsmanship, coupled with the beauty of native stone collected right there on the property.

It was early afternoon when I put a bottle of water and an energy bar in my fanny pack. I took my camera, some extra film, my hammer and a rock pouch. Diane told me that it was some distance to the mesa where I might find petrified wood. I was told to stay on the main road to the windmill and water tank. This is a four-wheel-drive road, and I didn't even think of attempting to drive on it, let alone trying to negotiate the Cimarron River bottom. I set out on foot.

When I reached the river except for one pool of water off to the left, the bed was dry. The gravel bar to the right looked intriguing, so this is where I began my search.

It always seems to take a while at a new site for my eyes to get adjusted and to be able to identify what I'm looking for. This site was no exception, but it wasn't long before I spotted something different from the countless other ordinary rocks in this bar. It was a most unusual agate, a rose agate, and much different than I had anticipated. In many respects, it actually resembles a rose. The surface is mottled and lumpy with dozens of tiny bumps that are actually the color of a red rose. The main body of the stone is a creamy off-white, blended in with the red coloration here and there. It's the size of a small chicken egg. It wasn't long before I found another rose agate, not 20 feet from the first. This one is a prize. It has the same mottled, red surface, but a window had been cleaved in one side, revealing a wonderful light-blue core. This agate is about the size of a golf ball.

During my time in the dry river bed I collected several very nice agates. Most of them are rather large. They all have the appearance of being formed in a most hostile environment. Of course the material that these gemstones were formed in has long since eroded away and blended in with the dust. Only the hardness of this mineral has kept it from the same fate throughout the ages.

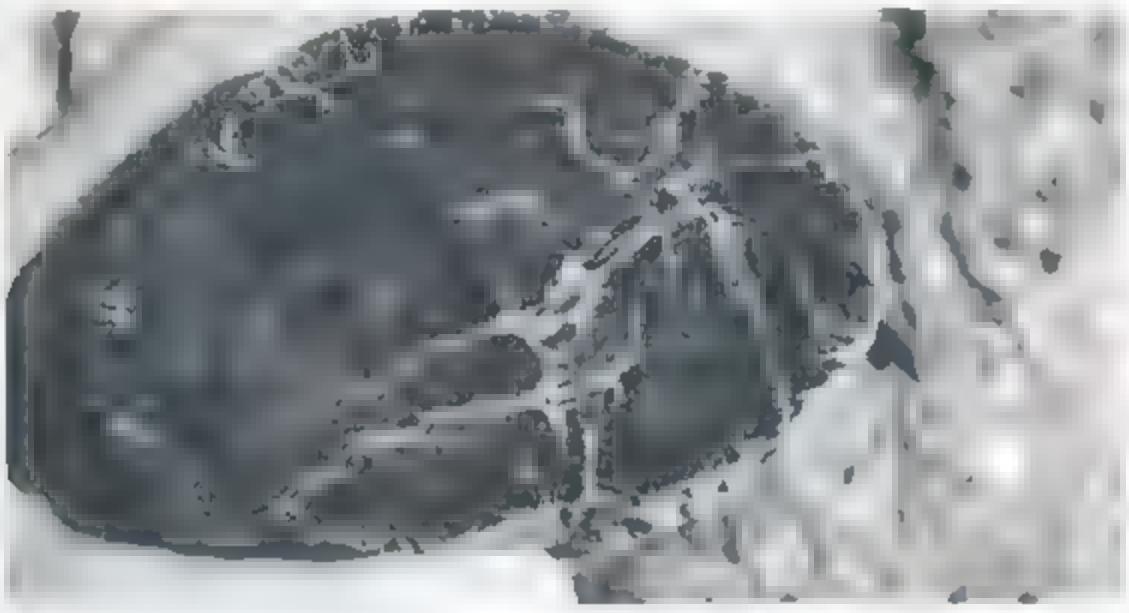
Later, after eating my energy bar, I walked slowly downstream in the dry bed of the Cimarron. The sun felt warm on my face and the chill of the morning was forgotten. In my slow pace I studied everything within sight, searching for anything that looked unusual. I had hoped to find a fossil form, perhaps a specimen of petrified algae or a shark tooth. I found some very unusual rocks in that river bed during my walk, but no fossils. I did however manage to find a beautiful piece of chocolate-colored agatized wood with a creamy white outer rind. In the surface of that specimen are two holes about [illegible] men in diameter. One of those holes is quite deep, evidence of the workings of a worm that lived here millions of years ago.

The sun was already slipping toward the western mesa when I decided to walk along the 4X4 road toward the windmill. I must have walked for at least 30 minutes. At a good pace, I can usually walk about two miles in this time. Due to the fact that I stopped to examine exposed rocks and boulders along the road, I must have covered less than half that distance.

It was getting late and I still hadn't reached the windmill. There are other roads that lead off in different directions along the way, and this confused me a bit, but I spent another 15 minutes trying to reach the windmill. I stopped at a deep gully, had a drink of water and admired a large, old tree that spread its branches well over the road. I used it as my landmark for future reference. This was where I turned around and headed back. I would have to ask Diane whether I had actually taken the right road. I saw no signs of petrified wood on either side as I walked along. Tomorrow would be a whose new day of adventure.

Back at the ranch headquarters, I explained to Diane how I had not found any petrified wood during my hike. She offered to take me to the windmill in the morning. I was allowed to camp on the property at no charge. A cold front had moved in during the afternoon and the night was cold, with the temperature at daybreak hovering below freezing. After breakfast, I walked over to the house. It was my last day at the ranch, and I hoped it would warm up a bit.

When I told Diane how far I had gotten along the road in my quest for petrified wood, she smiled and said that from my explanation I actually had taken the right road. I just hadn't gone far enough. She started her 4X4 pickup and we were off to the windmill. In a matter of minutes, we were across the river and headed right along the same road that I'd walked



This beautiful polished section of petrified wood can be seen at the ranch headquarters.

on the afternoon before. When I pointed out the tree where I had stopped the day before, Diane laughed and said, "You were almost there! Just a bit more around this bend and over that hill and you'd have been at the mill."

She was right. In minutes, I was getting out of the truck and thanking her for her help. She offered to come back in a couple of hours and pick me up. I thanked her, but said I could use the exercise. Sitting at the keyboard during the winter months does little for physical fitness. The walk would do me a world of good.

With the sun higher in the sky, it began to warm up. I soon had my jacket open as I headed toward the high mesa to my right. It appeared close, but in reality it was quite a hike. When I reached the mill, the water in the cattle tank was as clear as a crystal.

Once at the mesa, it wasn't long before I found wood; I encountered my first fragments as I climbed the slope. They were white. The bands are not that distinct, but the coloration is outstanding. I didn't climb all the way to the top. There was really no need. I found several pieces of wood here and there, simply lying on the surface. I saw no evidence of partially buried wood anywhere on the slopes.

Later, I strolled over to the opposite mesa, and before I had gone even a fourth of the way up, I discovered numerous pieces of petrified wood scattered all over the surface amongst the juniper trees. Some are huge. I did not discover any of the gigantic log sections similar to those in the Smith's driveway. However, I was told that some very large logs are scattered here and there in the area. The largest piece I took back weighs just under 6 pounds. I simply couldn't resist it, it's that beautiful. The outer shell is a creamy light brown, with dark brown to gray growth rings clearly visible in it. It measures 6 inches by 5 inches by 3 ¼ inches.

The Smiths charge $1 per pound for their rocks, a most reasonable fee. If you don't desire to walk the distance, they have a select pile of petrified wood right in their yard that you can pick from. As mentioned earlier, the river is but a stone's throw from the ranch house, and I had no trouble collecting several rose agate specimens there. A word of caution. The Cimarron River is not always dry as I found it. During spring runoff and wet weather, it may have flowing water.

For more information and reservations, write to L.G. and Diane Smith, P.O. Box 72, Kenton, OK 73946, or call (405) 261-7410. You can camp on the property or travel to Black Mesa State Park, a short way from the ranch, where camping is available. There are no facilities at the ranch, so a self-contained camper is ideal.

Also, you have the unique opportunity to stay at Black Mesa Bed & Breakfast. This wonderful old house was built of native rock in 1910 and is two miles north of Kenton on state Route 8. The establishment is owned and operated by Monty-Joe and Vicki Roberts. For more information, call (800) 821-7204 or (580) 261-7443, or e-mail bmbb@juno.com. Pets are welcome with advance notice.

I was told that the Smiths allow year-round collecting, weather permitting. It gets a bit cold during the winter months, but warm weather comes early here. Just the same, it pays to be prepared for anything Mother Nature has in store.

I was happy as I walked back to the camper that afternoon. I had spent the better part of the morning all alone in this vast land of mesas and valleys. My pail was half full of wonderful petrified and agatized wood, and I even found more rose agates along the way back. It had been a most exhilarating experience. The memories will stay with me for quite a while.

GOLD AND GEM HIGHWAYS

ROADSIDE PANNING SITES IN ALABAMA

Part II

Coosa, Elmore, Etowah, Jackson, Lee, and Madison Counties

by David and Clois Walker

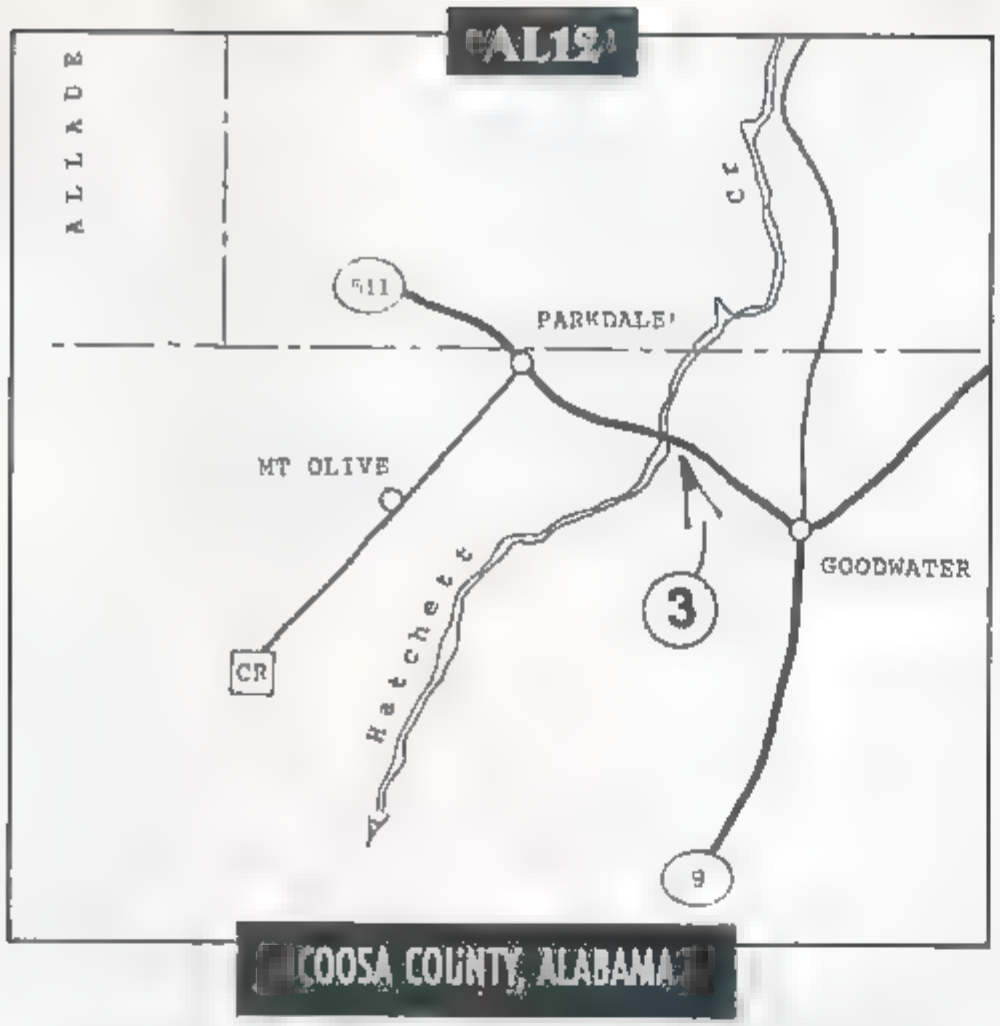
This is the second in a continuing series of county-by-county maps indicating the location of suggested panning and screening sites at a number of the more strategic highway/stream crossings, where appreciable finds have been previously reported on upstream watersheds.

Obviously, a highway-convenience study of this kind is most advantageous for seniors and others to whom tramping over hill and dale is less than attractive. It also eliminates the necessity of locating and obtaining permission from landowners. Remember to follow the usual safety and environmental guidelines when using highway rights of way.

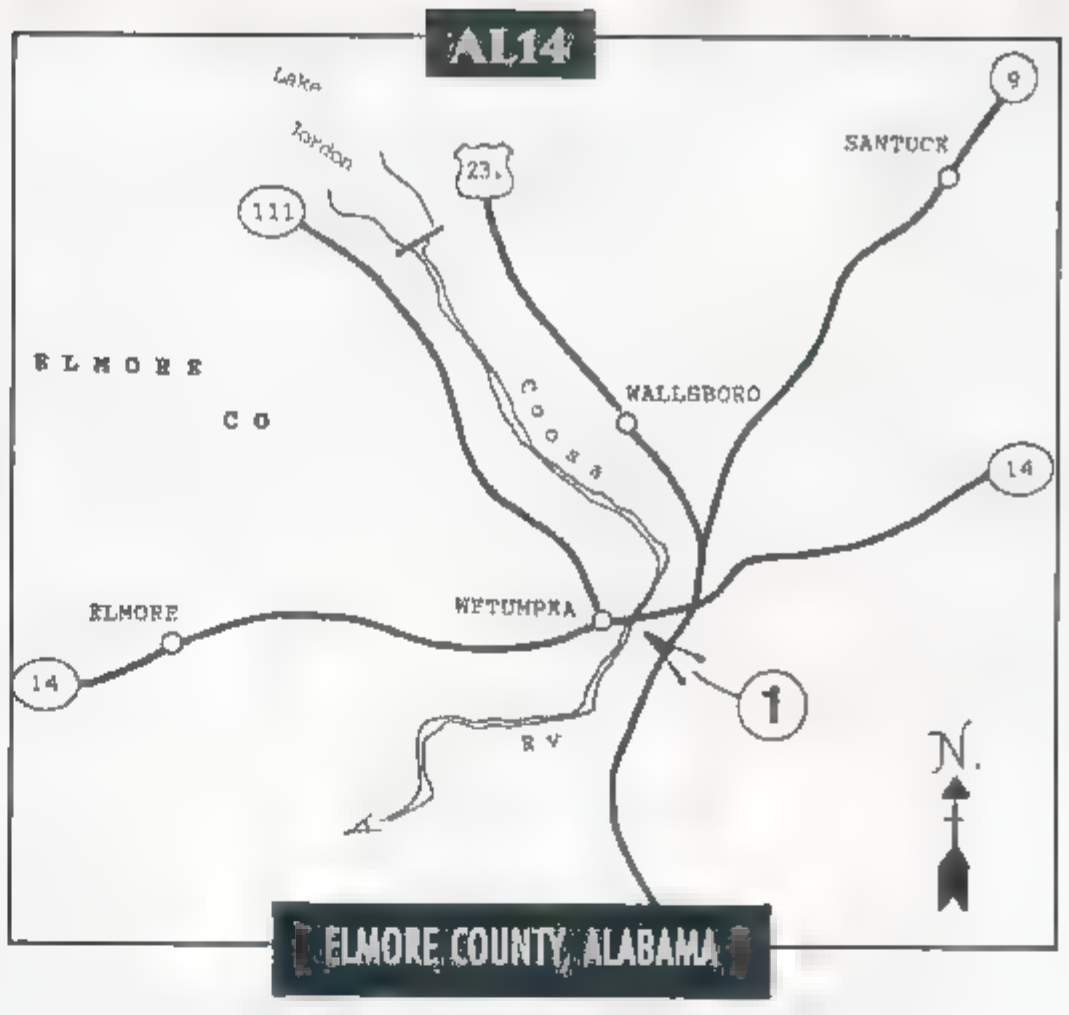
Though we have provided the most accurate information available to us, we recommend you refer to a current state highway atlas for orientation in the field as highway numbers and designations have been known to change.

LOCATION AND VICINITY FINDS IN ALABAMA

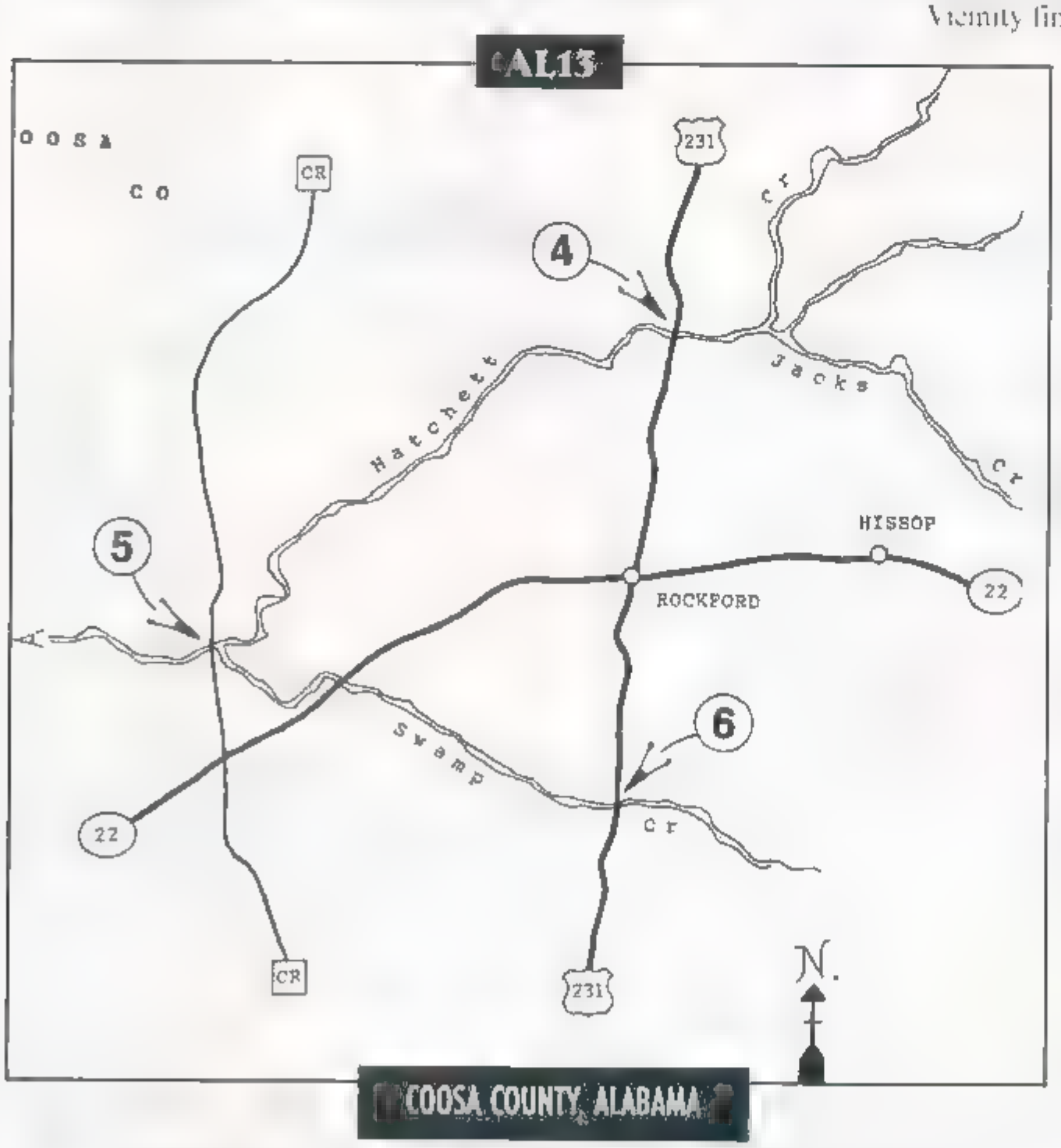
Coosa County (Maps AL11-13)
Site 1 **Hatchett Creek/state Route 21** crossing, near **Stewartville.** Vicinity finds include gold and pearl
Site 2 **Tributary of Hatchett Creek/state Route 21** crossing, near **Stewartville.** Vicinity finds indicate gold potential

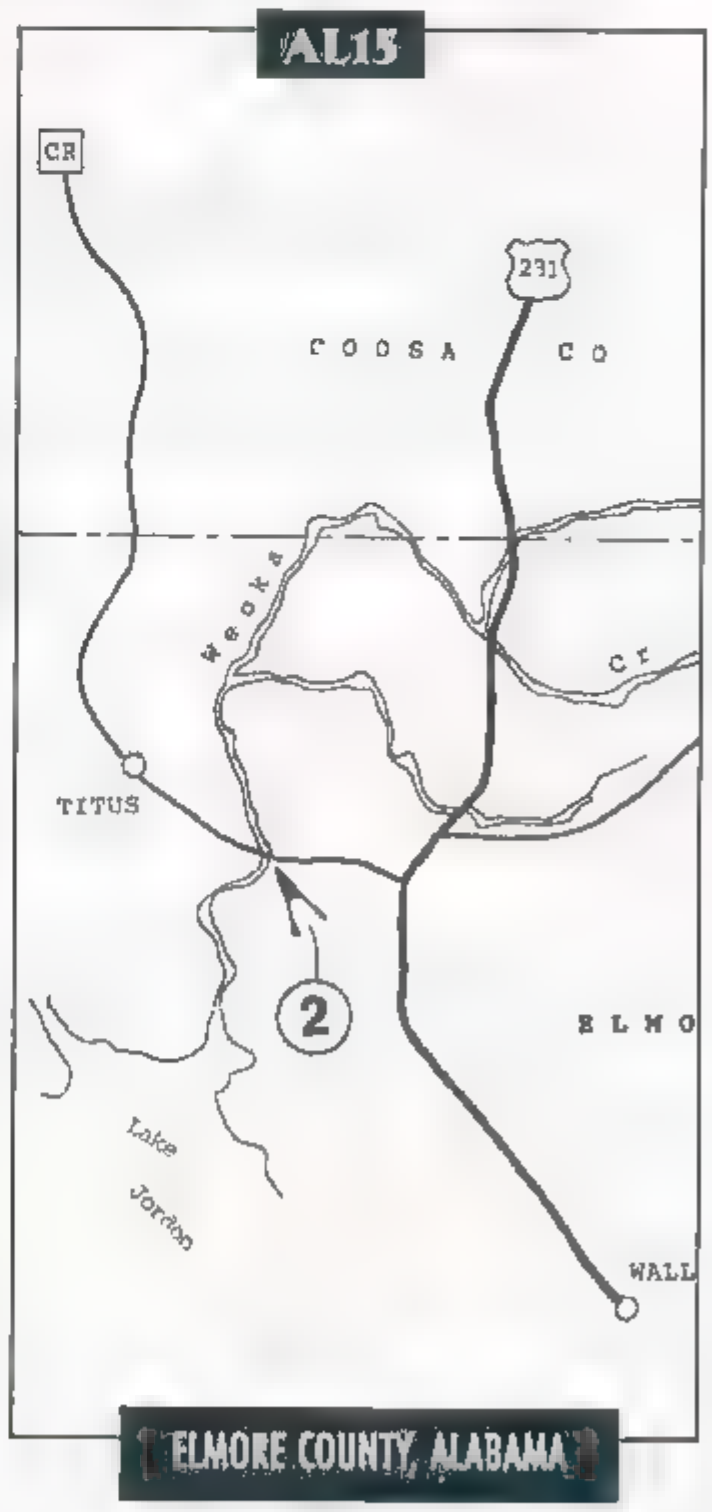


Site 3 **Hatchett Creek/state Route 511** crossing, near **Goodwater.** Vicinity finds indicate gold potential



Elmore County (Maps AL14-16)
Site 1 **Coosa River/state Route 14** crossing, near **Wetumpka.** Vicinity finds include quartz and silicified wood





Site 4 **Hatchett Creek/U.S. Highway 231** crossing, near **Rockford.** Vicinity finds include gold and pearl
Site 5 **Hatchett Creek/County Road** crossing, near **Rockford.** Vicinity finds include gold and pearl.
Site 6 **Swamp Creek/U.S. Highway 231** crossing, near **Rockford.** Vicinity finds indicate gold potential.

Site 2 **Weoka Creek/County Road** crossing, near **Titus.** Vicinity finds indicate silicified wood potential.

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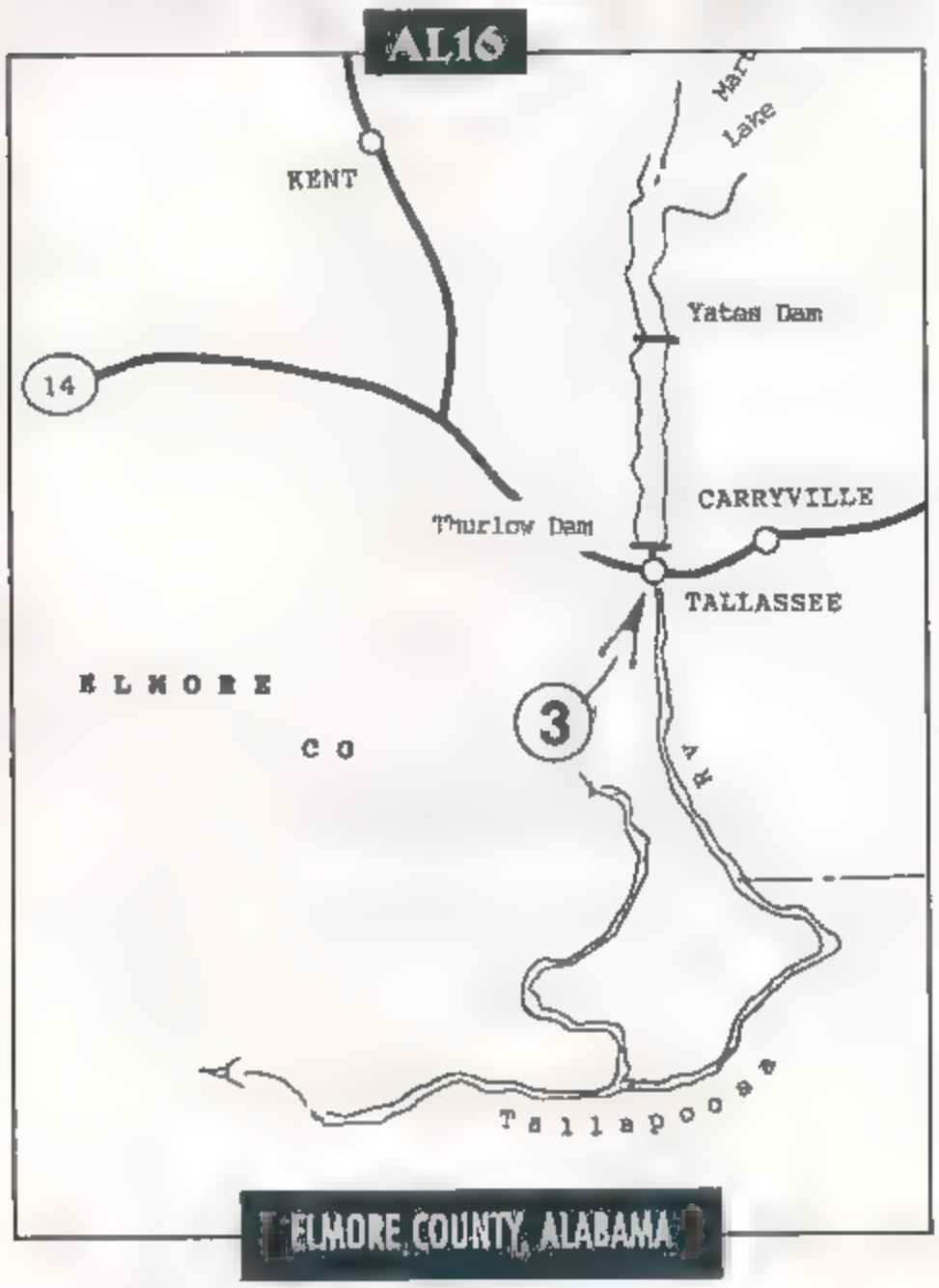
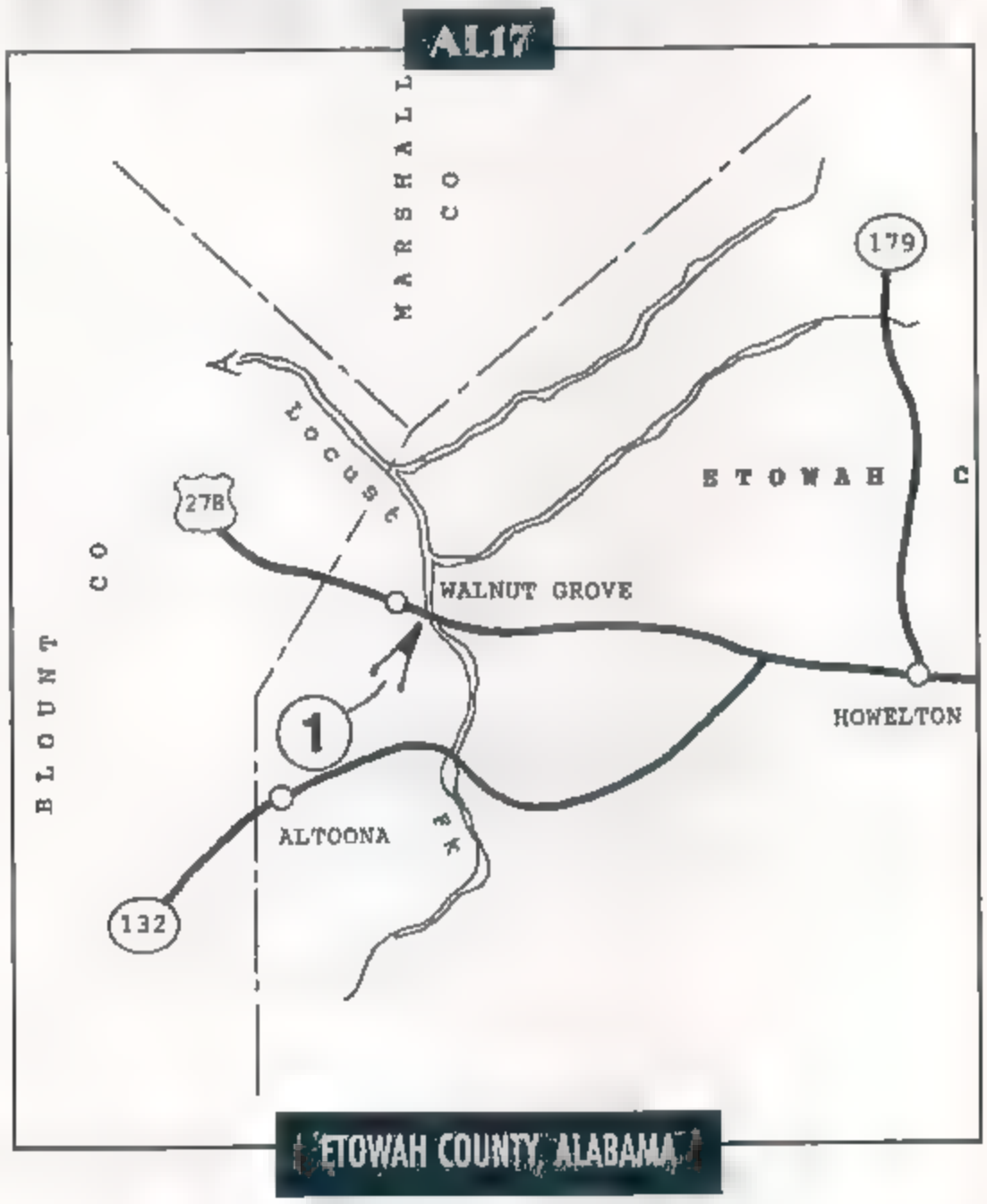
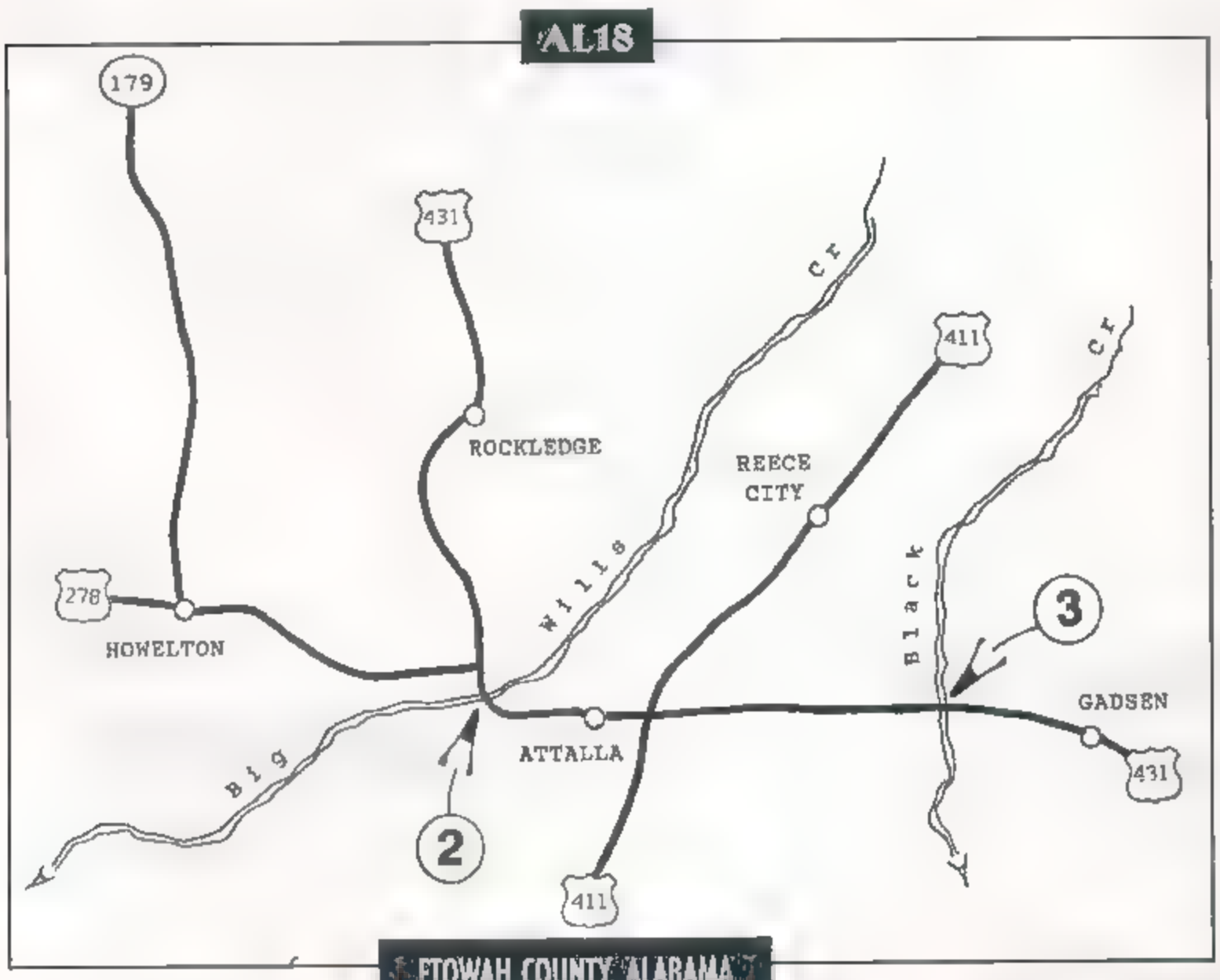


Site 3 **Tallapoosa River/state Route 14** crossing, near **Tallassee.** Vicinity finds include gold, rhodonite, rutile, and tourmaline



Etowah County (Maps AL17-18)
Site 1 **Locust Fork/U.S. Highway 278** crossing, near **Walnut Grove.** Vicinity finds indicate rhodonite potential



Site 2 **Big Wills Creek/U.S. Highway 431** crossing, near **Attalla.** Vicinity finds indicate rhodonite potential
Site 3 **Black Creek/U.S. Highway 431** crossing, near **Gadsen.** Vicinity finds indicate rhodonite potential

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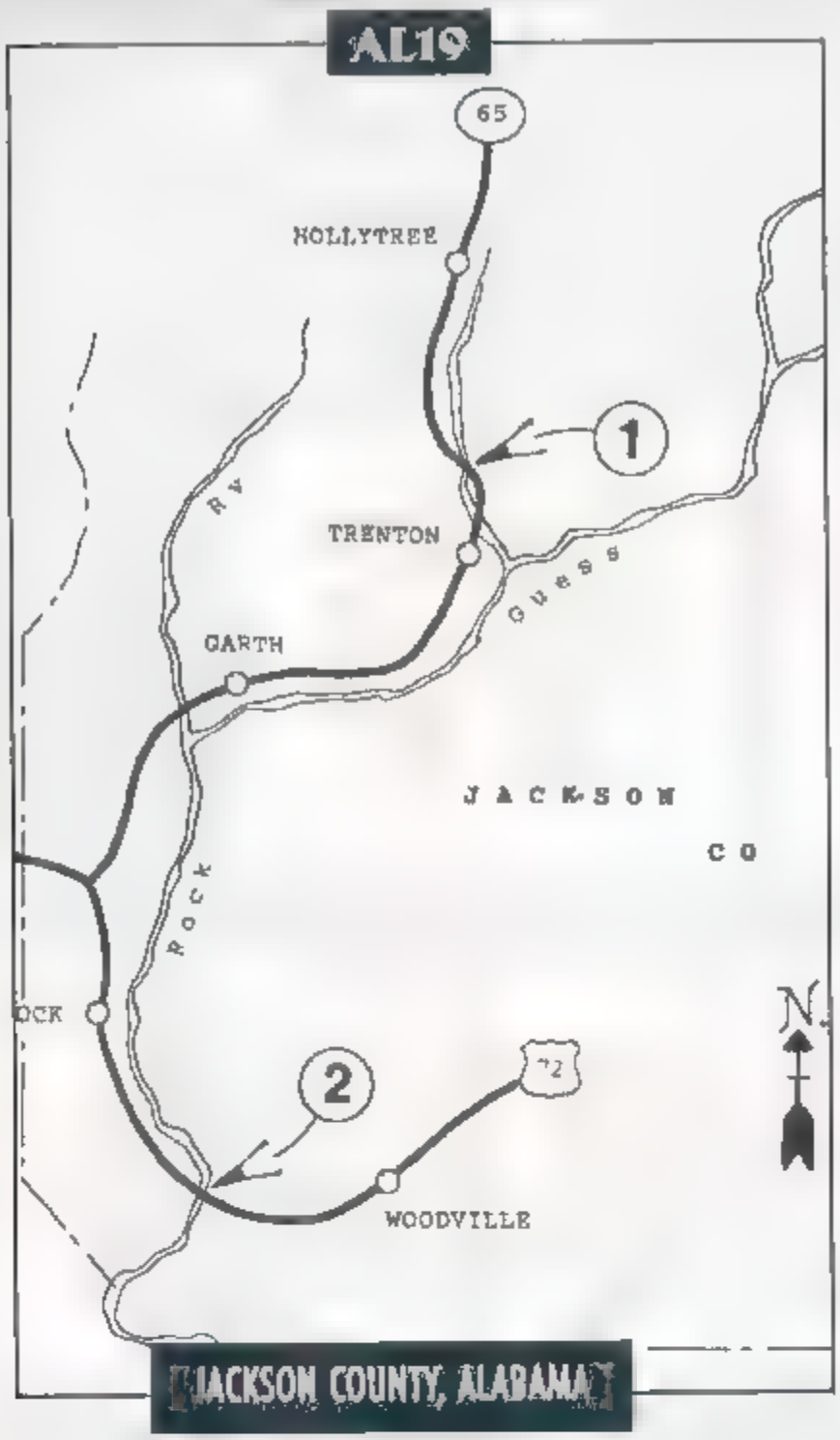
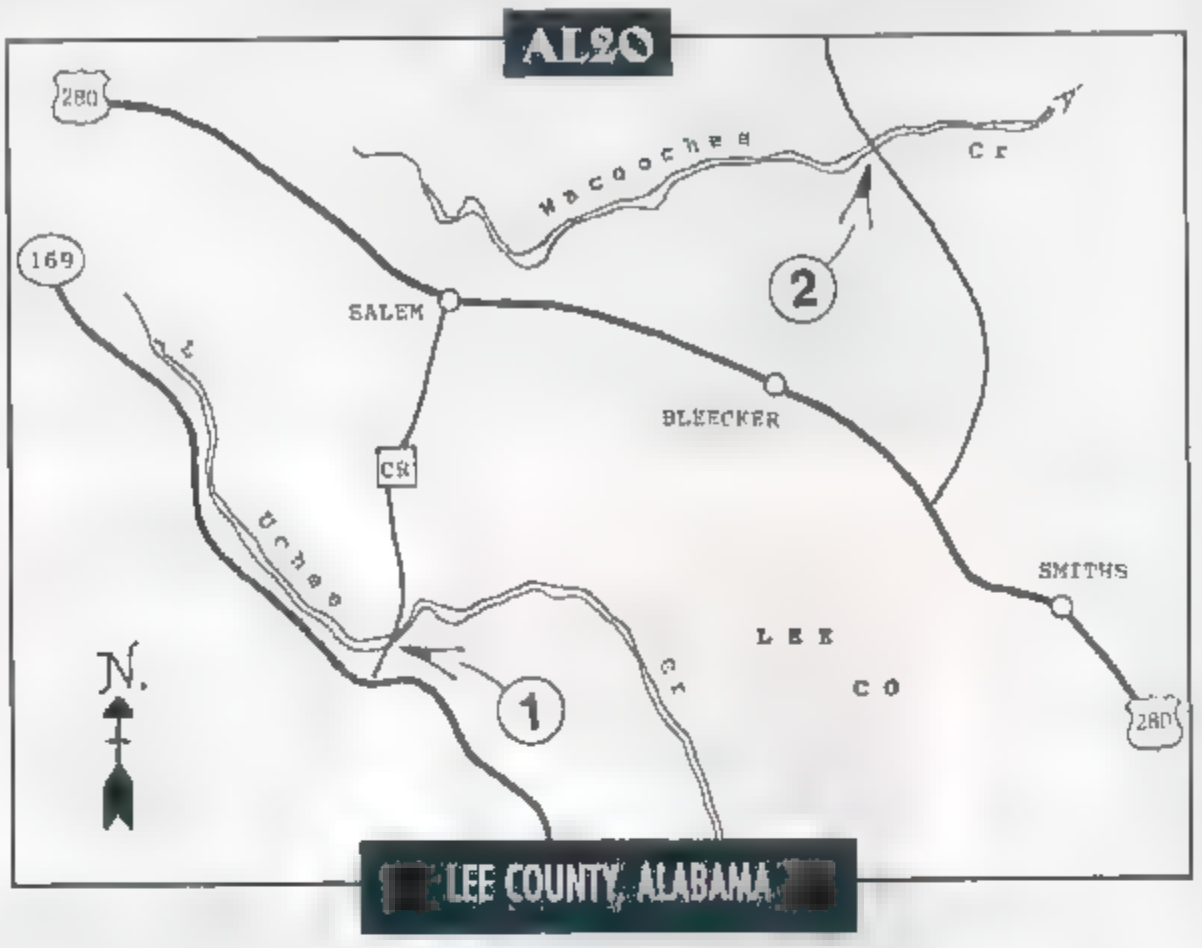
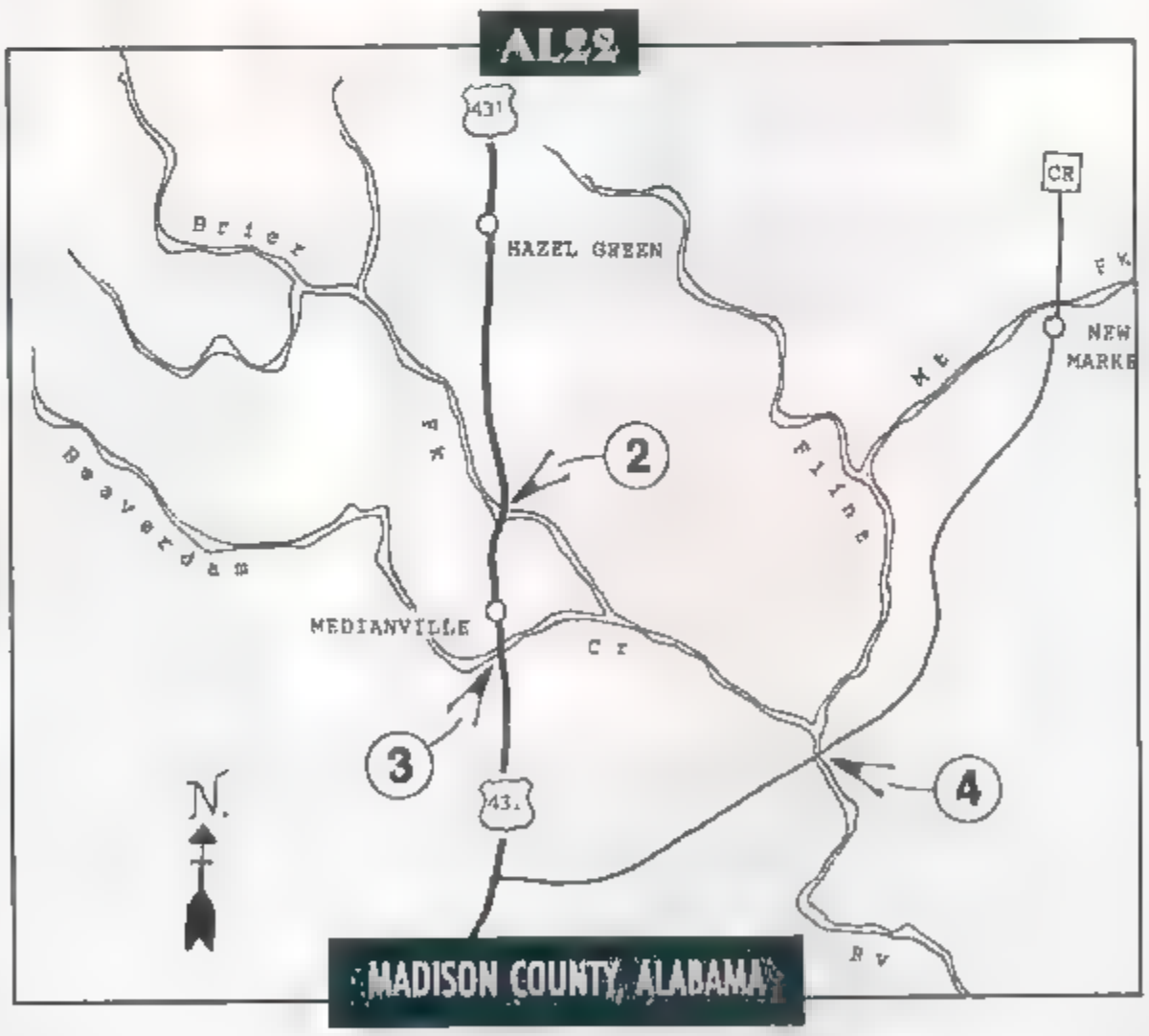
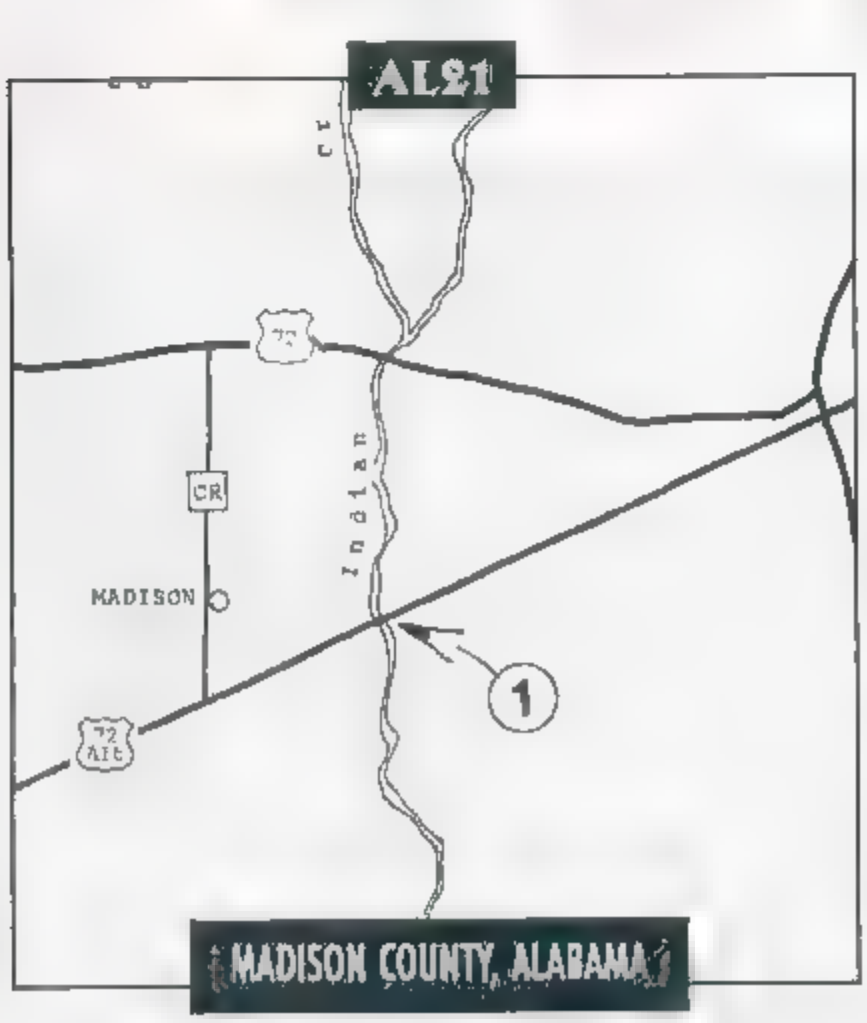


Jackson County (Map AL19)
Site 1 **Tributary of Guess Creek/state Route 65** crossing, near **Trenton.** Vicinity finds include agate, chalcedony and quartz
Site 2 **Rock River/U.S. Highway 72** crossing, near **Woodville.** Vicinity finds include agate, chalcedony, jasper, and quartz



Lee County (Map AL20)
Site 1 **Little Uchee Creek/County Road** crossing, near **Crawford.** Vicinity finds include diamond, jasper and quartz
Site 2 **Wacoochee Creek/County Road** crossing, near **Smiths.** Vicinity finds include diamond and quartz





Madison County (Maps AL21-22)
Site 1 **Indian Creek/U.S. Highway 72 Alt.** crossing, near **Huntsville.** Vicinity finds indicate agate potential.
Site 2 **Brier Fork Flint River/U.S. Highway 431** crossing, near **Medianville.** Vicinity finds include agate, jasper, and silicified wood
Site 3, **Beaverdam Creek/U.S. Highway 431** crossing, near **Medianville.** Vicinity finds include agate and chalcedony
Site 4 **Flint River/County Road** crossing, near **Medianville.** Vicinity finds include agate and quartz

Use the official state highway map in conjunction with the vicinity maps for overall orientation in the field

KINGSTON QUARTZ

Starburst Crystals in New Mexico's Black Range

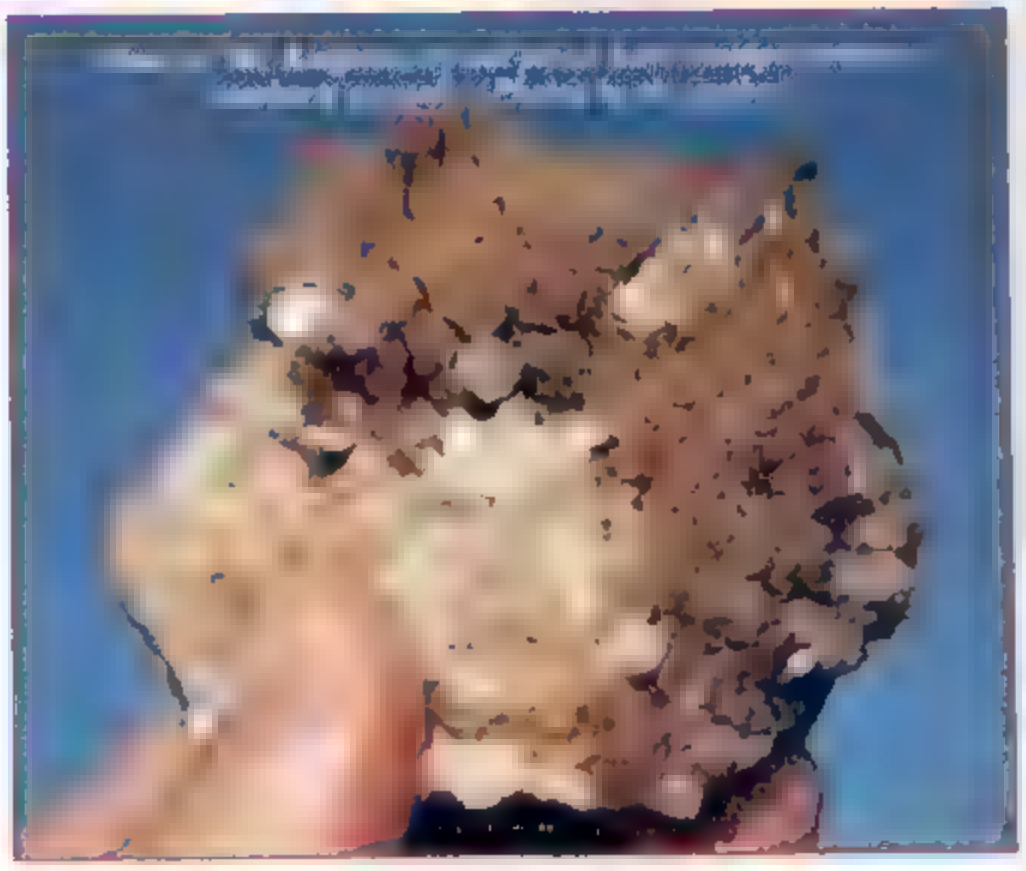
by Robert Beard

New Mexico place names have long reflected the trials and tribulations of early New Mexicans. The Jornada del Muerto, Satan's Pass, and Lost Man Canyon all testify to the hardship and death experienced by the first New Mexicans. According to *The Place Names of New Mexico* by Robert Julyan (University of New Mexico Press), the state also has at least two Dead Mans Canyons, a Dead Mans Arroyo, and a Dead Mans Peak. All of these names were likely well deserved. However, perhaps the most appropriately named place in New Mexico was known to the Spaniards as the Sierra Diablo, or the Devil Mountains. Today, it is known as the Black Range.

Mountains around the world share the designation black range, as mountains often appear dark when viewed from a distance. The Black Range in New Mexico is especially well named. The mountains not only look black, but have deep, dark, and often menacing canyons. When the sun passes over the mountains in the early afternoon, shadows cover the ravines and chasms of the eastern side of the range, and the darkness plays tricks on your eyes and with your head.

In some parts of the Black Range, especially on the western side, the terrain is less sinister, but it is still easy to lose your bearings. Sometimes, you cannot see the sun for the trees, and all the ground looks the same. The feeling of being lost in the woods quickly becomes sickening when you realize that you really are lost.

In the 19th century, the Black Range was an Apache stronghold with dangerous mountain lions and bears. A reference to the Black Range as the Sierra Diablo is also found in *Black Range Tales*, by James McKenna (The Rio Grande Press Inc.). McKenna describes the area as a perfect paradise, especially after a rainy season, but the Apaches kept settlements from being established in the Black Range until 1872. The Black Range was undoubtedly among the most hazardous places in the territories in which to be a prospector or settler.



Today, the Black Range is considerably safer but not without hardships. There are many excellent mineral collecting sites in the deserted silver mines and bedrock outcrops, but they can be a nightmare to access. They are often well off the main roads, and you sometimes have to hike a long way, even if you have a good four-wheel-drive vehicle.

An exception to the typical Black Range collecting site is the Kingston quartz crystal locality, which is just off one of the few two-wheel-drive roads that access the range. There is just enough hiking and climbing to keep the less ambitious collectors from coming to this place. It has the huge advantage of being within Gila National Forest Land and away from patented mining claims, and collecting is permitted.

I have been to this site numerous times, and even go to it whenever I am in the area on trips to other sites, as the area is extremely easy to access and always produces excellent crystals. The quartz crystals occur in outcrops of silicified zones and quartz veins along hillsides, and there is a large area in which to explore and collect sizeable starburst quartz crystals.

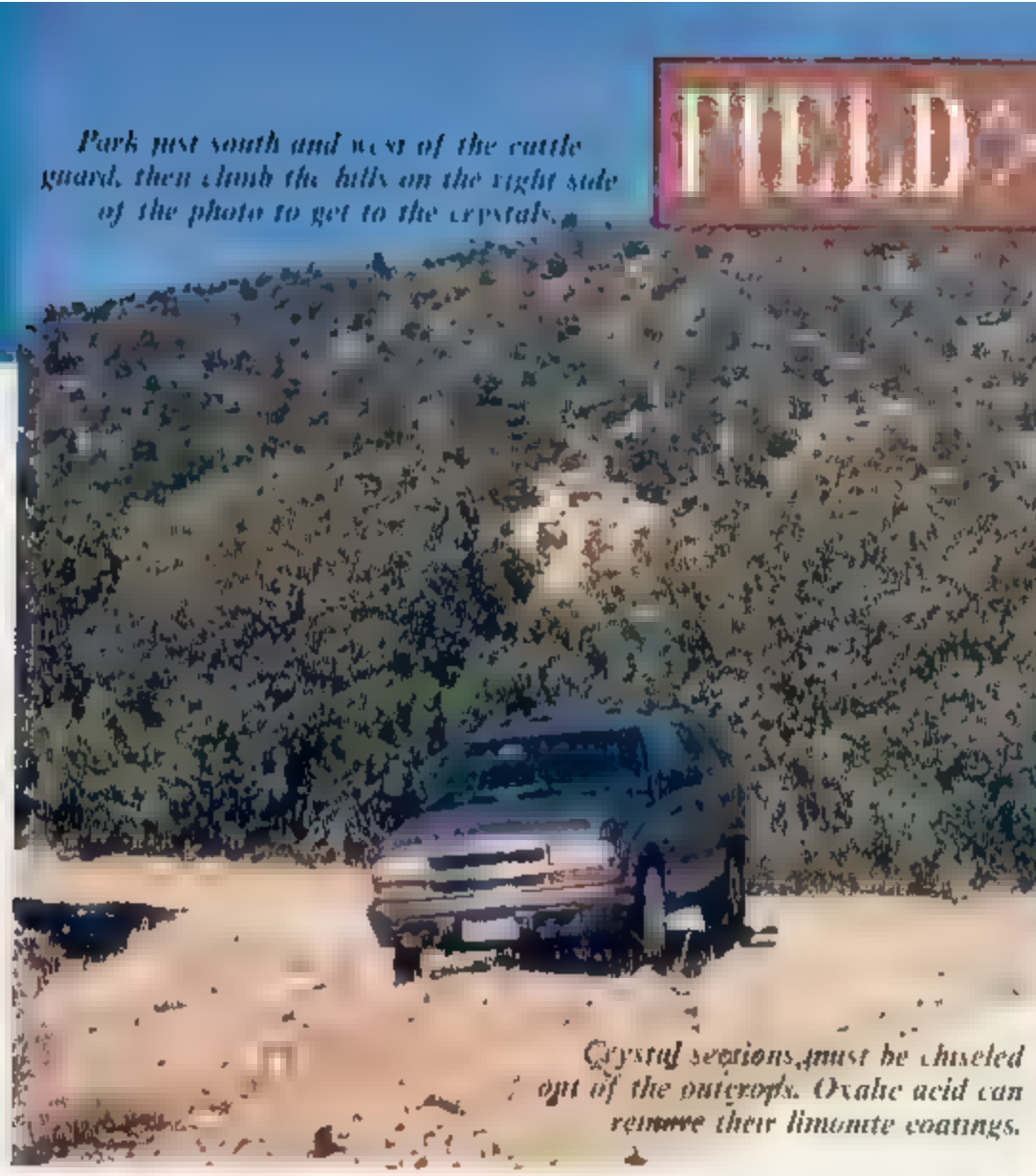
I had spent many years collecting in the Black Range before I learned of the site through *Gem Trails of New Mexico* (Gem Guides Book Co.). Although this well-known publication lists the site, I have not talked personally to many people who have collected here. It is just enough out of the way to keep throngs of collectors away, while still accessible enough that you can easily go if you are in southwest New Mexico.

Kingston is a small town on state Route 152 and is approximately nine miles west of Hillsboro, New Mexico. I have also seen some maps that show state Route 152 as state Route 90, so know that this can be a source of confusion if you have an older map. Kingston is one of the original settlements that started when silver was discovered in this part of the Black Range around 1880. According to *Place Names*, the town was laid out by the Kingston Townsite Co. and named for the Iron King Mine. Once the silver mines played out and the price of silver crashed in 1893, Kingston all but faded away.

The ore deposits of the Kingston mining district were primarily replacement deposits in Paleozoic carbonates. The mines were mainly to the west and northwest of Kingston. The Gila National Forest Map, available at the U.S. Forest Service station in nearby Truth or Consequences and at map supply stores, is

FIELD TRIP

Park just south and west of the cattle guard, then climb the hills on the right side of the photo to get to the crystals.



Crystal sections must be chiseled out of the outcrops. Oxalic acid can remove their limonite coatings.

extremely useful for showing the roads, mines, and land status of the area. According to this map, many of the Kingston area mines became patented claims, and as such are now private land. Patented claims on Forest Service maps are generally easy to spot, as they are white, roughly rectangular blocks at various angles in the green Forest Service land. I personally have not tried to get access to these areas in recent years, so I am uncertain of their collecting status.

The area is shown on the USGS 7.5 minute topographic quadrangle entitled Kingston, New Mexico, and you can check the area very easily at www.topozone.com. This topographic map shows that most of the mines in the Kingston district are in groups to the west and northwest of Kingston. However, these are located in the same areas of the patented claims on the Gila Forest map. If you decide to explore the mines, pay attention to any no trespassing signs and be aware that some of these sites may be private land.

The geology of the Kingston area is complex. Detailed geologic mapping and aeromagnetic work over many decades has indicated that the area is along the eastern structural margin of the Emory cauldron, which is a complex Tertiary-age volcanic center. In simple terms, the Emory cauldron was formed by the collapse of a massive volcano and subsequent resurgence of magma into the collapse zone. The Spanish word for cauldron is *caldera*, and the large basin-shaped depression formed by collapsing volcanoes is also often called a caldera.

The rocks of the volcanic complex are well exposed on state Route 152 as the highway steadily climbs to the crest of the Black Range. The highway crosses the crest at Emory Pass, which *Place Names* indicates was named in 1939 for Lt. William H. Emory, who crossed the Black Range in 1846 with Kit Carson and the Army of the West. This pass is one of the most scenic vistas in New Mexico, and offers an excellent view over the eastern Black Range towards the Rio Grande valley. If you go to Kingston, you should take the time to drive up Emory Pass so you can grasp the extent of the Black Range. If you arrive in late afternoon on a clear day, you will see the shadows as they begin to fall over the canyons and gain an appreciation of what the early visitors felt as darkness descended over the range.

Understanding the geology of volcanic terrains can be extremely difficult, as the rocks are often heavily altered by hydrothermal fluids and extreme heat. It is often tough to distinguish sedimentary rocks from volcanic rocks, as many rock units of volcanic origin, such as ash flows and ash beds, sometimes have features similar to sediments. The volcanics and sediments of a cauldron complex are often heavily faulted, and figuring out the structure can be extremely complicated. Add tree cover, talus slopes, and rugged terrain, and it becomes a very tough area in which to do geologic mapping.

I first visited the Kingston quartz crystal site in the summer of 1996. I came to the locality based on information from *Gem Trails*. I was not sure what to expect, as my experience in the area indicated that most of the mineralization was in carbonates, and I was not aware of any good quartz crystals in the Kingston district. I had collected quartz crystals and other rocks in the Chloride district in the northern Black Range, but was often frustrated with the difficulty of accessing that area.

The directions given in *Gem Trails* were simple to follow, and I was very pleased to see that the road to the site was easy to drive on and well maintained. I did not encounter any major ruts or other features that would prevent a low-clearance vehicle from getting to the parking area. I parked near the crest of the road near a cattle guard, I then walked to the reported area of the crystals.

Climbing up the slope to the crystal locality was a little tougher than I expected. There are no well-defined trails or old roads that lead you to the outcrops. I was wearing shorts and a short-sleeve shirt, and my arms and legs were soon covered with cuts from thorns and brush. There were numerous yucca and cacti, and I was lucky that I did not slip and fall into them. The rocks on the hillside are loose and it is easy to slip if you are not careful.

I watched the ground and found several small hand samples with quartz crystals, but I was looking for larger specimens. I soon found some very large outcrops of quartz on the backbone of the small ridge that I had climbed. These were the exposures of large sheeted zones, and many of them had large open spaces that were lined with well-terminated quartz crystals. Most of the quartz was white to translucent, but the crystals were generally well-formed.

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I soon picked a spot to focus on with my hammer and chisel. I worked on breaking out the larger sections of crystals to be used for display pieces. I also had to keep the size reasonable for transportation purposes, since I had to fly back from New Mexico and could not take 20-pound pieces in my luggage.

This hillside takes the full brunt of the sun during the day. Many other sites in the Black Range are often dark by early afternoon as the sun goes below the canyon ridges and tree lines. The sun and heat became intense, and sweat burned my eyes and made it difficult to see. I made a big mistake of not having a hat or gloves on this trip to the site. I got so wrapped up in hammering that my hammer actually flew out of my sweat-soaked hand as I blindly banged away on the rocks.

Flying chips from the quartz and my hammer further cut up my hands, arms and legs. Chips from the hammer are the worst, as the sharp, dense steel flies off with much more force than a comparably sized piece of quartz. This can be dangerous if you are hammering next to fellow collectors.

During this trip, I found excellent pieces of starburst quartz. These are aggregates of quartz crystals that radiate from a central point, and the pieces were generally 1 to 3 inches wide. The best piece that I found was about 2.5 inches wide and had uniformly terminated quartz crystals. Many of these make excellent display pieces, and often break off the outcrop with a flat base. It takes some time to find the best pieces, as you often have to find a large section in a vug and break it down. Alternatively, if you look on the ground surface, you are also likely to find some good starburst crystals. Many of the crystals have a coating of limonite, and I was able to remove some of the limonite with an oxalic acid solution that I bought at my local hardware store.

I was surprised that I did not see pyrite, chalcopyrite, malachite, or other indications of metallic minerals in the quartz outcrops, except for some minor limonite staining. It is also apparent that there are very few prospect pits in this area. In many mining districts, any showings of quartz or vein material were often dug out and thoroughly explored by prospectors, and the lack of many diggings suggests that the quartz outcrops are barren of the gold and silver sought by prospectors. This has worked to the advantage of mineral collectors, as none of the quartz crystal outcrop areas have become patented mining claims which are private land and often off-limits to collectors.

I have returned to the site many times since, and during my latest trip in fall 2002, I recorded the GPS coordinates of the site. The parking area is located at 32° 55.825' N, 107° 42.896' W. One of the large silicified outcrops with crystals is located at 32° 55.717' N, 107° 42.515' W. For those without a GPS unit, the crystal-bearing area can be located using the section, township, and range system. It is at the SE1/4 of the NW1/4, Section 7, T. 16 S., R. 8 W.

Every time I have been to the site, I have been so busy looking for quartz crystals that I have not checked host rock geology. I later treated some of my samples with oxalic and hydrochloric acid, and I did not see any evidence of carbonates. My impression was that the host rocks for the quartz crystals were volcanics, based on the lack of any bedding in the outcrops and the slightly rounded hillsides. I have checked some large-scale geologic maps of the eastern Black Range, but they did not show enough detail to conclusively determine the bedrock geology of the quartz crystal collecting area.

To get to the site, take state Route 152 into Kingston. As previously mentioned, some older maps indicate that state Route 152 has been called state Route 90. Immediately after you enter Kingston, there is a fork to the right off state Route 152. Take this fork, and then take the very next right, which will be a dirt road. Proceed approximately 0.7 mile uphill to the crest of the hill at a cattle guard. Turn around and park, and climb into the hills to the east. You will find numerous pieces of quartz crystals on the ground and in the numerous large silicified outcrops.

The outcrops have a virtually unlimited supply of quartz crystals for the motivated collector. It is nearly impossible to over-collect this site, as there are always more vugs and openings that have crystals. The biggest challenge is to cull your finds to a manageable amount, and to keep yourself safe from flying quartz and steel, and the snakes, spiders and scorpions that may lurk in the outcrops.

With the proper precautions, this is a good site to take kids and families, providing the kids are big enough to hike around without falling off the outcrops or into a cactus. It is reasonably easy to get to, and everyone will find some excellent crystals. The sun shines nearly all the time on the collecting zones, unlike many of the dark and foreboding canyons of the Black Range. With a well-planned trip, you may not even know that you are in what was once known as the Devil Mountains.

London's Natural History Museum houses a replica of the most complete Baryonyx, a meat-eating dinosaur from Europe. (Photos by the author)

A Visit to Britain's Natural History Museum

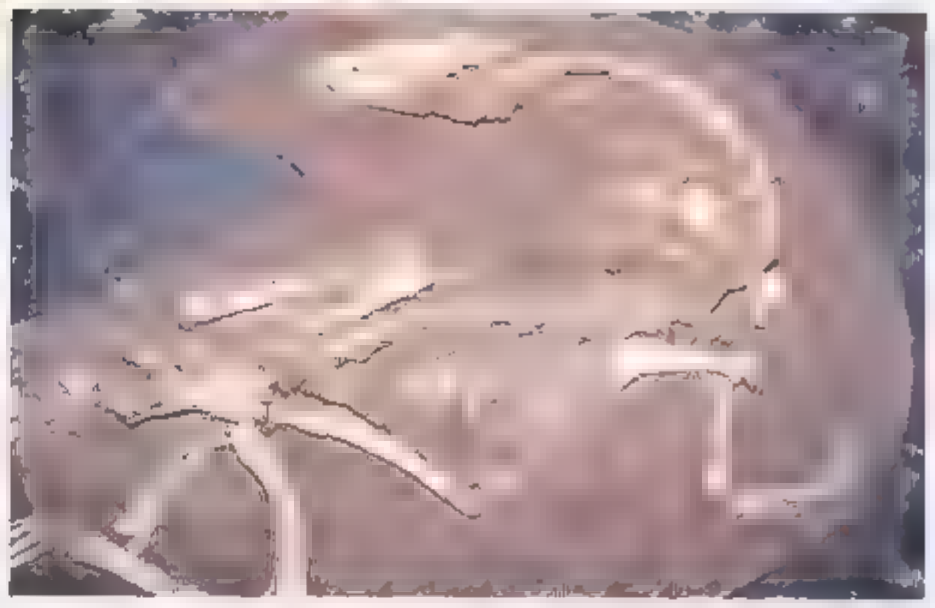
by Murray Eiland

The Natural History Museum in London, England, has had a long association with dinosaurs. Prof. Richard Owen (1804-92) was instrumental in putting pressure on the British government to build a museum that was to set the standard for the natural history palaces of Europe in the 19th century.

Owen was considered "lazy and impudent" by his teachers. Destined for a life at sea, he switched careers in 1820 and became a surgeon's apprentice. Anatomy captured his interest, and he was soon convinced that life was not the result of material forces alone. His search for the "vital principle," or "soul," led him to London to study under the tuition of the greatest surgeons of the day. He was appointed to the Royal College of Surgeons in 1826.

The Royal College had a vast collection of anatomical specimens, and Owen was drawn into pure science rather than medicine. He also was charged with dissecting and preserving any animal that died in the London Zoo. The anatomy of many living animal species was essentially his field, which was a critical step in his later discoveries of extinct species. In 1839, he was given a bone fragment from New Zealand that he suggested was from a giant, flightless bird, which he named Dinornis (the extinct Moa). Owen was given the task of examining bones of large reptiles that had been found in Southern England. In 1841, he gave a lecture in which he grouped these extinct animals (Iguanodon, Megalosaurus and Hylaeosaurus) into the Lacertian or Squamate division of Class Reptilia. At this time, along with most other people, he considered them the remains of giant, extinct lizards.

Owen made a critical intellectual leap as he was writing up the final report. He carefully examined the sacral vertebrae of Iguanodon and found that they were fused. The fused vertebrae were like the examples of Megalosaurus he examined, but were unlike any living animal, and certainly unlike any modern lizard. He named this new group of animals the Dinosauria in his report, published in 1842. Thus, he is credited with first naming dinosaurs. He made a further report that is still widely cited today. In 1863, he wrote on the famous Jurassic bird Archaeopteryx.



Left: An excellent fossil exhibit in Gallery 63 marks time from "the beginning" to the present. Below: Some of the best skeletons in the museum, such as this Coelophysises, are casts.

Perhaps not surprisingly, Owen and Charles Darwin did not get along. They had similar interests, and, as in many academic environments, this led to strife. The fact that Owen and Darwin stood on opposite sides of the religious debate did not help matters. Owen disagreed with many points in Darwin's book *The Origin of Species* yet this did not stop him from looking closely at the organization of the natural world. Perhaps his greatest contribution is the Museum of Natural History in London. When entering through the main (Life Gallery) entrance, look for his statue presiding over the main hall at the top of the stairs on the first level.

In 1856, Owen was appointed Superintendent of the natural history collections in the British Museum, yet the museum was not as it stands today. It was no more than an appendage in an art museum. The basis for the natural history collection that was eventually to become a museum was formed by the collection of Sir Hans Sloane, he willed specimens to the nation upon his death in 1753. Somewhat strangely, the collection was housed with other "curiosities" and much later.

Owen campaigned for a new museum to be built separate from the archaeology building, and in 1873 a new museum was started. It wasn't finished until 1881. Terracotta tiles decorate the inside of the structure. The tiles on the western wing picture living things, while those on the eastern wing show creatures from the distant past. Perhaps not surprisingly, many of the animals, past and present, show how an archetype, or common structural plan, is preserved in vertebrates. Owen was the first to suggest that similar structures – a flipper, bat wing, or human hand – reflect a common pattern. Perhaps strangely, a basic paleontological concept originated from a religious conviction. Owen was looking for a philosophical basis for life, in effect, searching for a unifying vital principle that animated all life.

While many of his anti-Darwinian theories were the subject of ridicule at the time, and some suggested that his work would be soon forgotten, Owen's name has continued to be associated with dinosaurs. His efforts in promoting natural science and the building of the museum are also a tangible reminder of his presence.

The Natural History Museum is one of the first to use cast iron and steel to any great degree. It reflects the opulent taste of the Victorian age, and is a London landmark even without its contents. In 1963, the natural history museum was officially separated from the British Museum and given its own trustees. In 1986, the museum incorporated the Geological Museum, which had been built adjacent to it in 1935. This explains why the current museum is divided into Life Galleries and Earth Galleries. A new gallery called Lasting Impressions was built to link the two museum buildings together in 1988.

The pride of place given to dinosaurs is clear from entering through the Life Galleries entrance. The huge Diplodocus skeleton, while stunning, may disappoint some. It is only a cast, but it was donated by Andrew Carnegie. His casts grace many museums in Europe, which no doubt helps to raise the status of America in some quarters. Considering that there are about 9 million specimens in the paleontology department and about 10,000 dinosaur specimens, there is plenty to see besides a cast of an American dinosaur. The museum has one of the largest holdings of ancient life in the world. A list of the dinosaurs that the museum has, along with a summary of important information, can be found on the Eurodino Database Project (www.dinodata.net/EURODINO/Mus/london.htm). The dinosaur page of the Natural History Museum is also very useful (www.nhm.ac.uk/museum/lifegalleries/dinosaurs.html).

The Jurassic marine reptiles from Lyme Regis in Southern England, some of which may have been collected by Mary Anning (1799-1847), are in the hall near the gift shop. The site continues to pour forth fossils today, and in the late 19th century it was a popular holiday resort. People were willing to pay for small fossil souvenirs. The tide continually ate away at the cliffs, and regular quarrying for cement led to the exposure of many fossils. All that remained was for someone to collect and popularize them.

Anning lived when the study of ancient life was just starting, and she can be credited with finding spectacular specimens that increased the public's interest in palaeontology. This woman has been called the greatest collector of fossils in the world. She is credited with finding the first ichthyosaur fossil known by the British scientific community in 1809 or 1811. She was very young at the time, and according to contemporary accounts, her brother was the first to find the scattered bones, though she excavated the majority of the creature. The list of her finds is indeed impressive, and they came to rest in the great museums and aristocratic collections of Europe. She recovered the first nearly complete example of the Plesiosaurus while still in her early 20's and the first Pterodactylus macronyx in the United Kingdom. She also found Squaloraja, a fossil fish that proved to be a transitional link between sharks and rays, and finally the Plesiosaurus macrocephalus.

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London's Dinosaurs *from page 61*

It is interesting to note that at first the noted French scientist Georges Cuvier doubted the existence of the Plesiosaur on the basis of drawings, but later realized his error. To the modern eye many of these animals may seem familiar, but in the early days there were many fantastic reconstructed drawings, if not outright forgeries. Anning is also credited with finding the first pterosaur in England. Another fossil hunter, Gideon Mantell, found pterosaur remains before she did, but thought they were from a bird. Anning also made a discovery that made a minor sensation in the art world. She found fossil cuttlefish that still had remains of their ancient ink. This was used by several artists, who found that it was still of excellent quality.

Anning also understood what she was looking for. This was a rare talent when there was very little information about ancient life. Her scattered surviving personal accounts suggest that academics mined her knowledge. Anning was far removed from the upper levels of society, and the fact that she was a woman virtually precluded any recognition. She appears to have learned to collect from her father, who supplemented his income as a cabinetmaker by searching for fossils along the seashore. It was a dangerous and anonymous business. Many of her fossils that ended up in museums credited the donor who had purchased the fossils from her with their discovery. She had some well-to-do supporters who sought to give her credit as well as financial rewards, but even so it is difficult to locate her fossil discoveries in museum collections today. In the last years of her life, she was supported by an annuity from the British Association for the Advancement of Science (1838). The Geological Society of London gave her a stipend, and she was named the first Honorary Member of the new Dorset County Museum. Considering how much science owes to her work, it would be appropriate to have a suitable monument to her, as well.

The Natural History Museum can also host traveling shows, and dinosaurs are very popular. An excellent traveling exhibition outlined the theories of Jack Horner that were prompted by his discovery of one of the most complete Tyrannosaurus rex skeletons ever found, like whether this large dinosaur had killed prey or been a scavenger. Audiences were greeted by animated, life-size models of T. rex in various scenarios, as well as very impressive skeletal remains.

The museum is a center for research. The bookstore has a number of staff written publications. One of the best is a CD-Rom titled *PaleoBase*, available at the museum for the equivalent of $53. The CD is Part I of a larger project. It contains 50 records and 800 images from museum collections of Arthropods, Brachiopods, Bryozoans, Trace Fossils, Trilobites, and Graptolites. It is quite simple to install and use, and should be of interest to anyone with an interest in these fossils. A particular feature of the presentation is the ability to magnify images to look at fine detail. It will be a good aid to identifying hard-to-classify specimens. An online demonstration is available on the Web site www.paleobase.com. Part II, including Bivalves, Gastropods, Ammonoids, Nautiloids, Coleoids, and Early Metazoans, has also been published. Part III is due for publication in 2004.

A recent traveling show outlined the theories of Jack Horner that were prompted by his discovery of one of the most complete T. rex skeletons ever found.

After fossils, if there's time, it is well worth exploring the Natural History Museum's mineral collection. It is thought by many to be the finest in the world, though it had a disappointing start. As a wealthy doctor, Sloane had the money to amass a collection of about 200,000 natural curiosities, including geological specimens, which he left to the nation in 1753. He wanted the state to fund a museum to house his collection, but the state refused. The nucleus of the collections of the Natural History museum was subject to indifference. Out of some 8,649 geological specimens, many were assumed to be worthless and were buried or auctioned in 1803 and 1806. Today, only 161 objects – mostly worked objects – can be identified. Since about 1860, however, a number of other important collections have been purchased by or donated to the museum. In 1823, King George IV presented a collection of minerals from the Harz Mountains in Germany. This important mining region was of great interest due to economic concerns. In 1847, the Prince Consort to

The main part of the dinosaur exhibit considers the living animals: how they ate, moved and reproduced.

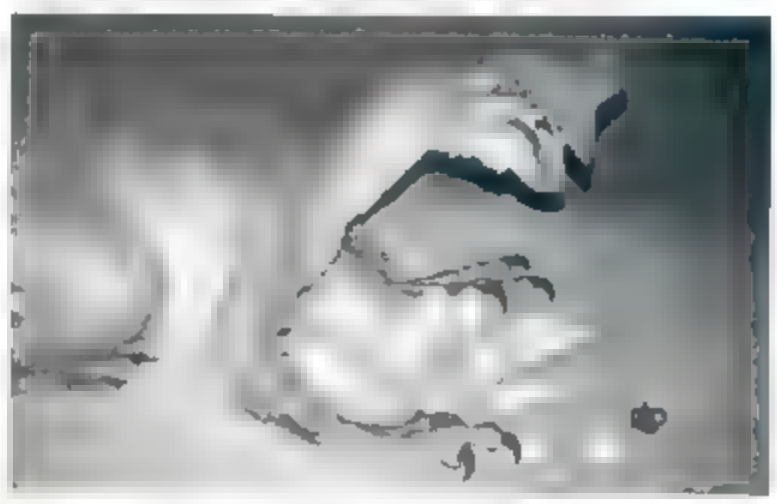
Queen Victoria presented a very large group of colorless, prismatic gypsum crystals from Reinhardsbrunn, Germany.

The museum now has some 350,000 mineralogical specimens, about 14,000 of which are on display. About 2,000 species are on display in Gallery 102 of the Waterhouse Building. Although there are introductory displays, the majority will be of great interest to specialists. Gemstones (Gallery 64) are a particular strength. The most recent addition to the collection was in April 1985, when about 3,000 gemstones were acquired after a merger with the Geological Museum. Gemstones from Burma and colored stones are well represented in a stunning display. The ambience is dark so that the inner structure of the gems is easily visible with directed beams of light.

It seems that few people understand what treasures are in these rooms. Not to be missed is the collection of diamonds on display from DeBeers. Many of the gems will be familiar from images in standard works on the subject. The museum holds 62 diamonds from the Hope collection, though the blue Hope diamond itself is absent. But there are other stars besides gems. A large specimen of crystallized galena from the Laxey Mine on the Isle of Man is said to be the largest crystallised sulfide specimen in any museum, and was acquired in 1850. In 1853, the crystallized "Latrobe" gold nugget from Victoria, Australia, was acquired. In 1875, a 1,142 gram platinum nugget from the Ural Mountains was purchased. In 1876, a 60 centimeter calcite crystal with one polished end to show double refraction was obtained from Iceland.

There is also a comprehensive collection of building stones, most of which is on the third floor of the Earth Science Galleries, totaling about 10,000 specimens. It documents United Kingdom and European rocks that are used for both decorative and structural purposes. Marble is arranged according to color, and building stones are arranged according to type (sandstone, limestone, etc). This collection has a real use in a national collection, as many building stones that have been exposed are now so weathered that they are difficult to identify. Most buildings are constructed with stone from various quarries, perhaps in several nations, so it is important to have samples of stones from particular locations. Restoration is made that much easier, and the display is of great use to the urban geologist.

The Natural History Museum also has a large collection of meteorites, totaling about 2,000 specimens. The first were acquired in 1802. There are several specimens of particular note: the Chassigny and Shergotty groups are now thought to be from Mars. There are also a number of



Several models, like this one of an Oviraptor, illustrate current thinking of what dinosaurs must have looked like.

meteorites from Antarctic expeditions. A large piece of the Nakala meteorite is on display in the atrium of the Earth Galleries. In 1959, the museum acquired part of the famed Nininger collection of meteorites.

With the Internet, there is no need to visit the Natural History Museum to hear and see lectures presented there. The Darwin Centre has a series of lectures, each lasting about a half-hour, that are available free online at www.nhm.ac.uk/darwincentre/live/archivelist.html. They are given by leading researchers in the field and pitched to a general audience. Seventeen lectures on paleontology are available, and a dozen lectures on rocks and minerals.

The museum is an easy walk from the South Kensington tube station (circle or district line). Underground information and maps are also on the Internet at http://tube.tfl.gov.uk/content/tubemap.default.asp. The museum is open every day, including Sundays and bank holidays, but is closed Dec. 24-26. Admission is free. Visit www.nhm.ac.uk/visiting/ for hours.

FIELD TRIP

ALABAMA'S COAL-AGE CORAL REEFS

Road Cuts Expose a Variety of Fossils

by Deborah Painter

As soon as I learned in January 2003 that I was being sent to Huntsville, Alabama, for a work-related course in early spring, I exclaimed, "Yes! Huntsville is fossiliferous!" I started mentally planning my strategy for using my free time for fossil hunting in the limestone reefs of northern Alabama.

Tropical reefs in the mountains of Dixie may surprise some folks, but these extremely old coral reefs are yet another reminder of how dry land has changed places with the sea and shore many, many times in the past, and will doubtless continue to do in the distant future. The lower Mississippian-period Tuscumbia formation comprises the flatter areas around Huntsville, about 700 feet above sea level, and the upper Mississippian Bangor, St. Genevieve, Gasper, Hartselle, and Pennington formations make up the mounds and hills of the town, as well as most of the nearby Monte Sano and Chapman Mountains. Monte Sano's uppermost peak is the lower Pennsylvanian Pottsville formation. There are no time breaks in the interfaces between formations.

Prominent road cuts in the western, northern and southern portions of the city expose the Tuscumbia Limestone, the principal bedrock for the flat portion of Huntsville and the rest of Madison County. Gasper and St. Genevieve occur in patches. These two are thick-bedded with crystals of pyrite. In addition to fossil hunting at road cuts, there are other geological sights to see, such as Monte Sano State Park right in Huntsville, and a private park about 60 miles west of Huntsville, advertised as having its own special, natural mystery!

I was able to devote a reasonable amount of time to three sites in the city of Huntsville. The first of them was a tributary of McDonald River near University Drive and Ben Graves Drive. Aside from the fun of meeting friendly ducks, I found the stream banks to be a "wash," unfortunately. However, two road cut sites fulfilled my expectations. Site 1 is at the intersection of University Drive and Sparkman Road along the southeastern flank of the Sparkman Drive overpass. Site 2 is the southern flank of Old Madison Pike, about 1.1 miles east of the Old Madison Pike Exit along Interstate 565, a few miles east of the airport. Site 2 can be seen from the interstate's westbound lane.

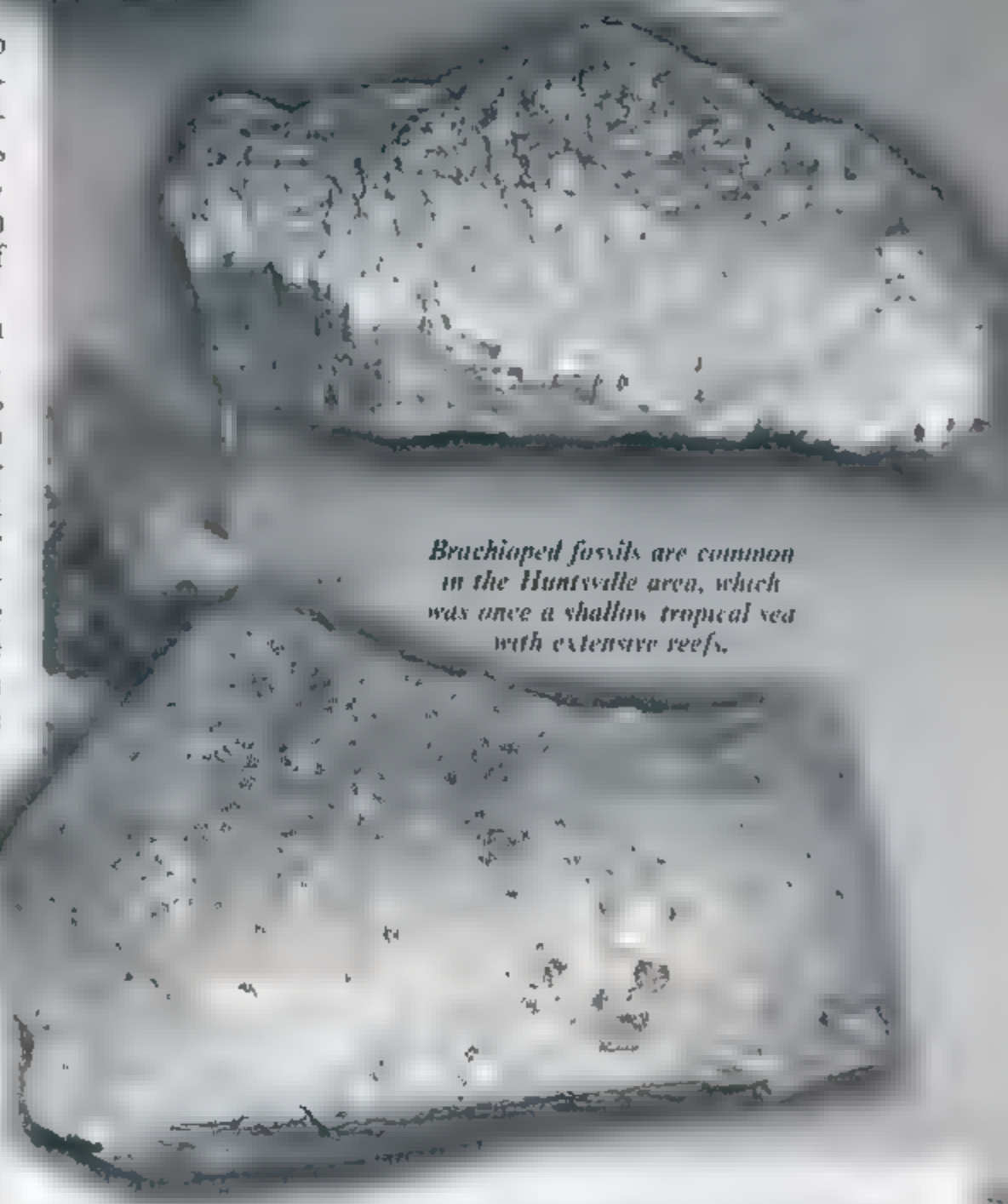
Site 1 (University Drive/Sparkman Road) is the larger of the two. There are doubtless more sites at road cuts all over the county. Road cuts along state highways are acceptable and legal collecting spots. When we rockhounds show that we understand common-sense safety and consideration of public property, state highway workers will be more agreeable to our presence in these areas.

Park at the small shopping area on Sparkman Road just to the north of the northeast flank of the intersection. When I visited in 2003, there was a convenience store, a car wash, a barbecue restaurant, and an oriental take-out restaurant. Parking is available at the restaurants. The site is an easy walk of a few hundred feet from the parking areas. The site is separated from the roadway pavement of University Drive by about 20 feet of mowed grass.

When working any and all road cuts, I recommend that you have everyone in your group wear blaze-orange safety vests. They are not expensive to obtain, usually $10 at sporting goods stores. If you are bringing any children along, caution them to stay close to the toe of the slope and not climb onto the higher crags, which are over 45 feet above the shoulder and are best left to experienced climbers with appropriate footgear and leather gloves. Be aware of the danger posed by bottles and other roadway litter obscured by vines and leaves along the base of the slope. Wear sturdy hiking boots for this site. The rocks are oolitic limestones, meaning that they have a texture like a mass of tiny eggs. The oolites, or round globes, are microfossils (shelled one-celled animal life called foraminiferans). You will have to use a geologist's hammer on this compact rock. Tuscumbia limestone is composed of these microfossils mixed with fragments of crinoid stems, bryozoans, and corals, with some blastoids included.

The limestone at Site 1 is approximately 300 million years old. Mississippian-period tectonic stresses affected the region to the southwest of the area we now call Alabama, and raised a new mountain range, the Southern Appalachians. Moving from west to east across the northern third of the state, from Colbert County to Madison County, one can trace the ancient lower Mississippian shoreline. In Colbert County, the coal-building forests of spore-bearers dominated the land nearest the dunes and the oceanside. The name "coal-age" evokes images of its famous giant scouring rushes and club mosses, 40 to 60 feet in height. Some fabulous trunks of these great "trees" have been collected there and are in the collection of the University of Alabama.

The area of Limestone and Madison counties, to the east of the seaboard forests of Colbert County, was a shallow tropical sea with extensive reefs. The tropical reef community was a colorful smorgasbord of brachiopods, gastropods, crinoids, edrioasteroids, solitary and colonial corals, sponges, and blastoids. Blastoids are extinct echinoderms, occurring as spherical or flattened animals. Related to the starfish and crinoid, the animals looked like a cross between a crinoid and a sea urchin and were usually less than 5 millimeters in width. Edrioasteroids, also extinct, were small, usually 2 to 3 centimeters long. These echinoderms looked like a starfish superimposed upon a sand dollar. They lived from the Cambrian to the end of the Mississippian and are represented in the St. Genevieve Formation by *Discocystis laudoni*. Crinoids and brachiopods are with us today.



Brachiopod fossils are common in the Huntsville area, which was once a shallow tropical sea with extensive reefs.

The fish of the Mississippian period included ratfish, sharks, and the earliest ray-finned fishes. Their fossils have not been found to date in Madison County's Mississippian marine strata. Perhaps conditions were not favorable for their fossilization. If you make a discovery of any vertebrate fossils, make careful notes of where you found the fossil. Please do not remove it from the bedrock until you have contacted a geologist with the Alabama Geological Survey.

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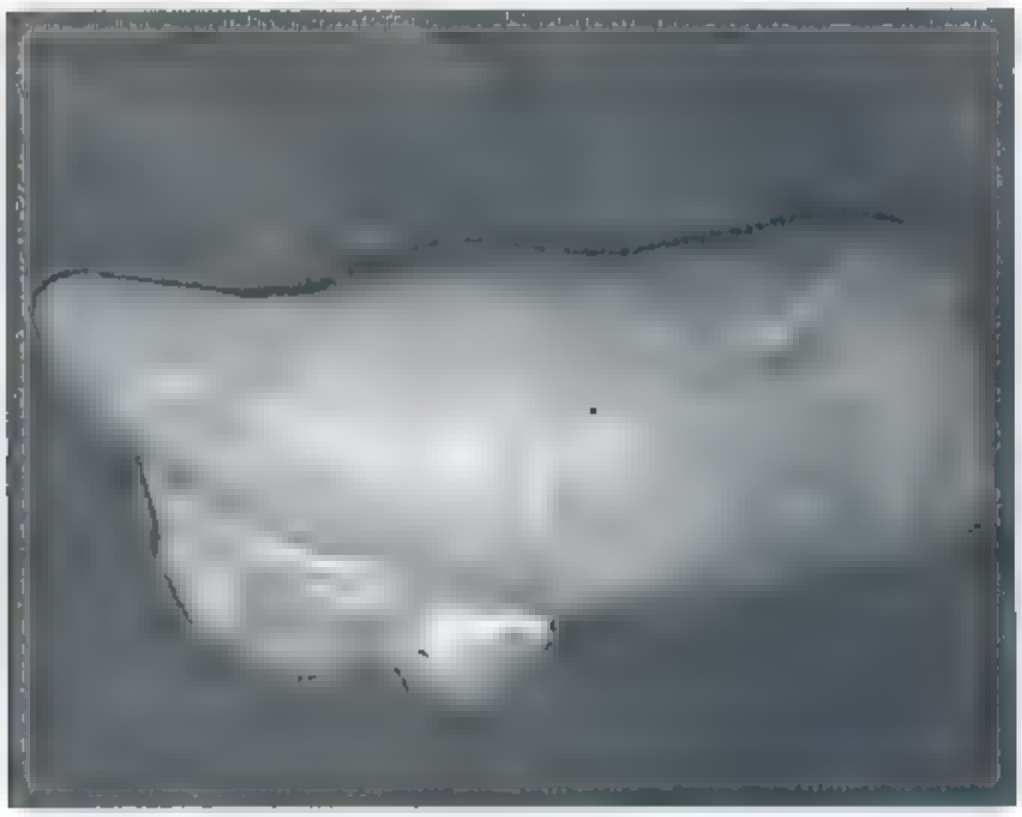
Alabama's Coal-Age Coral Reefs *from page 67*

If trilobites lived in the reefs of what we now call Madison County 300 million years ago, they must have been exceedingly rare, as their fossils have not been recovered there. The most conspicuous fossils are crinoid stems (*Platycrinites penicillus* and *Paracromis* species), brachiopods (*Diaphragmus cestriensis* and *Antiquatonia* species), blastoids (*Pentremites conoideus*), edrioasteroids (*Discocystis tatumi*), corkscrew bryozoans (*Archimedes wallowayi*), and sponges (*Pseudospongia lopadus*).



The calcareous skeleton of the rugose, or horn, coral housed a single large animal.

Horn or rugose corals (represented in Madison County and Colbert County by *Zaphrentis spinosus* and *Lonsdaleia cantelupensis*) are a very interesting old-fashioned order of corals. Extinct now, they appeared in the fossil record during the Cambrian and went extinct during the Permian. Named rugose for their wrinkled or ridged exteriors, they occurred as solitary animals (*Zaphrentis*) and in clusters (*Lithostrotionella*). Solitary corals were large, usually 4 to 8 inches at maturity, with each horn-shaped calcareous skeleton housing a single large animal. They shared the seas with tabulate corals, a more modern looking order of colonial corals that also went extinct in the Permian. Modern corals would not show up in the fossil record until the Triassic Period.

Modern coral reef ecology has been used by paleontologist J.A. Fagerstrom of the University of Nebraska and the University of Colorado as a model to help reconstruct the major roles played by the plants and animals in these ancient reef systems. Then, as now, some organisms served as baffles, physical obstructions that trapped sediment on level, shallow sea floors. By slowing the speed of the currents and waves, these organisms helped maintain quieter waters for other organisms. These included the crinoids and the bryozoans. The binders were the animals and plants which encrusted the sands. They included the lightly calcified green algae or rhodophytes, sponges, such as *Hexaokella costata* and *Pseudospongia lopadus*, the tabulate corals, and the colonial rugose corals like *Lithostrotionella*.

Then there were the dwellers: solitary, single-animal rugose corals, along with the active brachiopods, blastoids and edrioasteroids. The Tuscumbia Formation is noted for its abundant large chert nodules, indicative of either altered limestone or the presence of large numbers of silica-shelled microfossils such as diatoms. Diatoms were not part of the reef, but tiny, floating, silica-shelled algae that used photosynthesis to convert solar energy to carbon dioxide, oxygen, and food for the microscopic and larger living fungi of the reef. When they died, their shells sank to the sea bottom.

Cavities created by chemical weathering of the limestone surrounding the chert are prime den locations for poisonous copperhead snakes. Please use sticks to probe gingerly around the entrances to these cavities. Do not place your unprotected hand and arm in them.

Site 2, the mound-shaped road cut on Old Madison Pike, exposes the Tuscumbia Formation, as well as the Gasper and St. Genevieve. You can access it at the northbound Elko exit of I-565. A pull-off is available along the eastbound lane of Old Madison Pike, which parallels I-565 at this location and is very visible from the interstate. The mound-shaped, rocky exposure, covered with a carpet of grass on its crest, is nestled between the interstate and Old Madison Pike. The roadway provides a narrow, grassy shoulder about 10 feet wide. A railroad track runs between the collecting road and the roadway, please advise young people to keep their eyes and ears open and observe common sense railroad track safety when walking across the track. The mound is only about 30 feet high. Brachiopods, corals and crinoids are plentiful. As at University Drive, please be careful of poisonous snakes denning in the cavities between the eroded rock layers.

When you've finished collecting, enjoy some of the geological attractions in the area. The Burritt On The Mountain mansion, at the crest of Monte Sano just three miles east of town, boasts a display of local minerals and fossils, as well as the expected antiques. A local physician built the frame home in 1936 for his retirement. Burritt On The Mountain is open all year, only closing for major holidays. An admission fee is charged. Call (256) 536-2882.

According to my brochures, there are three commercial caverns, lakes, scenic hiking, trail riding, NASA's Space Camp, and the world-renowned U.S. Space and Rocket Center within the city limits or within 70 miles of Huntsville. In summer months, guides are available to take you to locations in the virgin forest of Dismals Canyon Wonder Park near the town of Phil Campbell, about 65 miles west of Huntsville off U.S. Highway 43. I learned about this park in a regional attractions brochure at the welcome center at the Huntsville Airport when I was waiting for my flight home. According to the short and understated description in the Northern Alabama tourist brochure, published by the North Alabama Tourism Association (www.northalabama.org), unexplained lights cart about among the small waterfalls and gigantic trees. The park has been designated a National Natural Landmark. I think the biggest mystery is, Why is this place not better known? I certainly will make a point to visit it next time I'm in Alabama.

The brochure advised that one should reserve group tours during summer weeknights to see the "Dismalites." Call (205) 993-4559 a week or two prior to your visit. The privately owned park has an admission fee. From March to October, lodges are available. During my next trip to Huntsville, I also plan to visit Russell Cave National Monument, within 60 miles of Huntsville, at 3729 County Road 113 in Bridgeport. Fossils can be seen within the walls of the cave, as well!

Before your visit, check the Alabama Geological Survey Web site, www.gsa.state.al.us, for information and color geologic maps. The Survey even has a good page on the legalities of collecting, how to label your fossils, and nearby geological attractions.

ROCK SCIENCE

by Steve Voynick

Water of Hydration

Most mineral collections include species with chemical formulas that end with "H_2O" or water. These minerals are called hydrates, and their contained water is known as "water of hydration."

Selenite, the transparent, crystalline form of gypsum, is among the most familiar hydrous minerals. It is a calcium sulfate with the chemical formula $CaSO_4 \cdot 2H_2O$. From that formula, we know that selenite's correct chemical name is "hydrous calcium sulfate," and that each selenite molecule is linked to two water molecules.

In hydrous minerals, the water of hydration is not simply absorbed, but is chemically bonded to the parent mineral's atomic structure. Water of hydration is not bonded as separate oxygen and hydrogen ions, but as integral water molecules that maintain their characteristic composition and structure.

Accordingly, selenite's chemical formula is written as $CaSO_4 \cdot 2H_2O$, rather than CaH_4SO_6. The chemical period (·) is a notational device that represents a chemical bond between two separate components of a compound. It most often appears in the chemical formulas of hydrous compounds to separate the water of hydration from the parent mineral.

In hydrous minerals, the water molecules are attached by hydrogen bonding, a weak type of bond that causes an inherent and broadly variable chemical instability. Unlike ionic and covalent bonds, hydrogen bonds form only between hydrogen atoms and other atoms. Although water molecules have overall electrical neutrality, the sites of the two hydrogen atoms within the water molecules carry a weak positive charge. And because the opposite sides of the water molecules have a small negative charge, they behave as tiny magnets. Hydrogen bonds, also called polar bonds, form when the positive poles of water molecules, that is, the hydrogen ions, weakly attract the electrons of other atoms. In hydrous minerals, the water of hydration is linked to the molecule of the parent mineral only by hydrogen bonding.

Hydrous minerals are unstable because hydrogen bonds are vulnerable to heat and have their greatest strength at low temperatures. As an example, hydrogen bonding between water molecules is the force that holds water together as solid ice at low temperatures.

Enough heat will eventually break all hydrogen bonds. In selenite, hydrogen bonds break at 150 degrees F to release the water of hydration as free water. The remaining parent mineral is anhydrous (devoid of water of hydration) calcium sulfate. The mineral form of anhydrous calcium sulfate is anhydrite, or $CaSO_4$.

Although selenite and anhydrite are both forms of calcium sulfate, their physical properties differ significantly. Selenite crystallizes in the monoclinic system, anhydrite in the orthorhombic system. At Mohs 1.5 to 2.0, selenite is much softer than anhydrite (Mohs 3.0 to 3.5). Also, water of hydration gives selenite a specific gravity of only 2.3, thus making it much less dense than anhydrite (specific gravity 3.0).

An example of an extremely unstable hydrous mineral is ikaite, a hydrous calcium carbonate with the chemical formula $CaCO_3 \cdot 6H_2O$. Ikaite is stable only in a saline, aqueous environment and at temperatures not much above freezing. Just a few hours of exposure to room temperatures cause its hydrogen bonds to part. Ikaite then decomposes into water and anhydrous calcium carbonate, or calcite ($CaCO_3$).

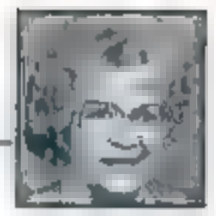
Yet other hydrous minerals are quite stable at elevated temperatures. Examples include turquoise (hydrous basic copper aluminum phosphate) and carnotite (hydrous potassium uranium phosphate).

Hydrous minerals are quite common and include the 22 zeolite species. Unlike most other hydrous minerals, zeolites can be dehydrated and rehydrated without altering their original crystal structure. The ability to dehydrate and rehydrate gives certain hydrous minerals, notably zeolites and gypsum, great commercial value as water filtration mediums and plasters respectively.

Hydrous minerals should not be confused with hydroxides, which have chemical formulas ending with the hydroxyl ion "OH." In hydroxides, the "OH" is ionically bonded to the parent mineral. An example is azurite, or $Cu_3(CO_3)_2(OH)_2$. Azurite's chemical name is "*basic* copper carbonate" or "copper carbonate *hydroxide*," and its formula has no chemical period between the copper carbonate and the hydroxyl ion.

In the end, the difference between anhydrous and hydrous minerals boils down to a few attached water molecules.

LAPIDARY LORE and MORE



by June Culp Zeitner

Big Holes in Minnesota

There is a big hole in Minnesota, sometimes called the Grand Canyon of Minnesota. It is the world's greatest open-pit iron mine, the Hull Rust Mahoning Mine, near Hibbing in St. Louis County. The mine shipped its first iron ore in 1895 and kept growing and expanding until it engulfed a town and measured three miles in length, two miles in width and over 600 feet deep. Parts of the enormous pit are now 100 feet underwater. Water pours in at the rate of 16,000 gallons a minute.

Hibbing is in the heart of the Mesabi Iron Range, which is almost 100 miles long. Parts of the Hull Rust Mine are still working. Gigantic shovels are at work and incredibly, large trucks can be seen carrying heavy loads of taconite out of the big hole. At first, hematite with 65 percent iron made the mine famous, but the still-plentiful taconite contains only 25 percent iron. The iron in taconite is magnetite. The ore is processed into taconite pellets, which are shipped by water to the steel mills of the eastern states. The ore is a cherty material.

A few miles from Hibbing is Chisholm, where a stone castle houses the Minnesota Mining Museum. It has models of a taconite plant and a blacksmith shop, and some early fire-fighting equipment. It also has an exhibit of ore transportation and a world map of mineral deposits.

The Mesabi is forested and has abundant lakes, water-filled old mines such as Lake Ore-Be-Gone. The Sherwood Forest Campground near Gilbert offers fishing, swimming, water skiing, and scuba diving. Considerable reclamation has been done in this whole area. Many of the historic buildings, walls and walkways were constructed by the Civilian Conservation Corps in the Great Depression era. The old Hibbing school once attracted much attention as being the best-planned, most modern, and best-equipped school of its day.

The minerals and gem materials of the Minnesota iron ranges include some that are unique. The Cuyuna Range is famous for binghamite, a quartz variation resembling tiger's-eye; its chatoyance is due to iron instead of crocidolite. Discovered by Bill Bingham in 1936, it displays hues of red and yellow with gleaming streaks of hematite. From the ancient Mary Ellen Mine near Biwabik comes Mary Ellen jasper, a richly colored and patterned lapidary material that is silicified algae. The 3.6 billion-year-old greenstone formation is also sometimes used for lapidary purposes. Jasper comes from Jasper Peak near Soudan. Hematite is used for jewelry. Lake Superior agates are numerous in the entire region. Some "lakers" have included copper.

The whole slab of binghamite looks better than the partials. (David Phelps photo)

The iron ranges were formed during the middle Precambrian. Major rocks are gabbro and diorite. Gold was once mined at Tower, but most minerals are iron related, with hematite being the most important. Others are groutite—first discovered in the Cuyuna range—martite and ramsdellite. Some of these contain manganese or magnetite. Goethite, marcasite and pyrite are also found in Mesabi mines. Quartz crystals are sometimes found on hematite, and red-coated quartz crystals are particularly beautiful. Ametnyst has been found occasionally, as well as smoky quartz.

The Ely's Peak Tunnel, a carved tunnel dug out of basalt in the 19th century, is 69 feet long. The area seems "mountainous," but is actually a series of bluffs, and is a popular ski area in the winter.

The landscape of the Mesabi is constantly changing. Old mines fill with water, and new mines are started nearby. Grasses, trees, flowers, and reeds slowly reclaim bare earth. Tons of overburden were used to construct the Leonidas Overlook and others.

The whole area is rich in history. Not far north of the iron ranges is one of the newer national parks, Voyageurs National Park. This watery trail was named for the early French Canadian fur traders who plied their canoes along the border gathering pelts. Long-abandoned gold mines are a feature of the park.

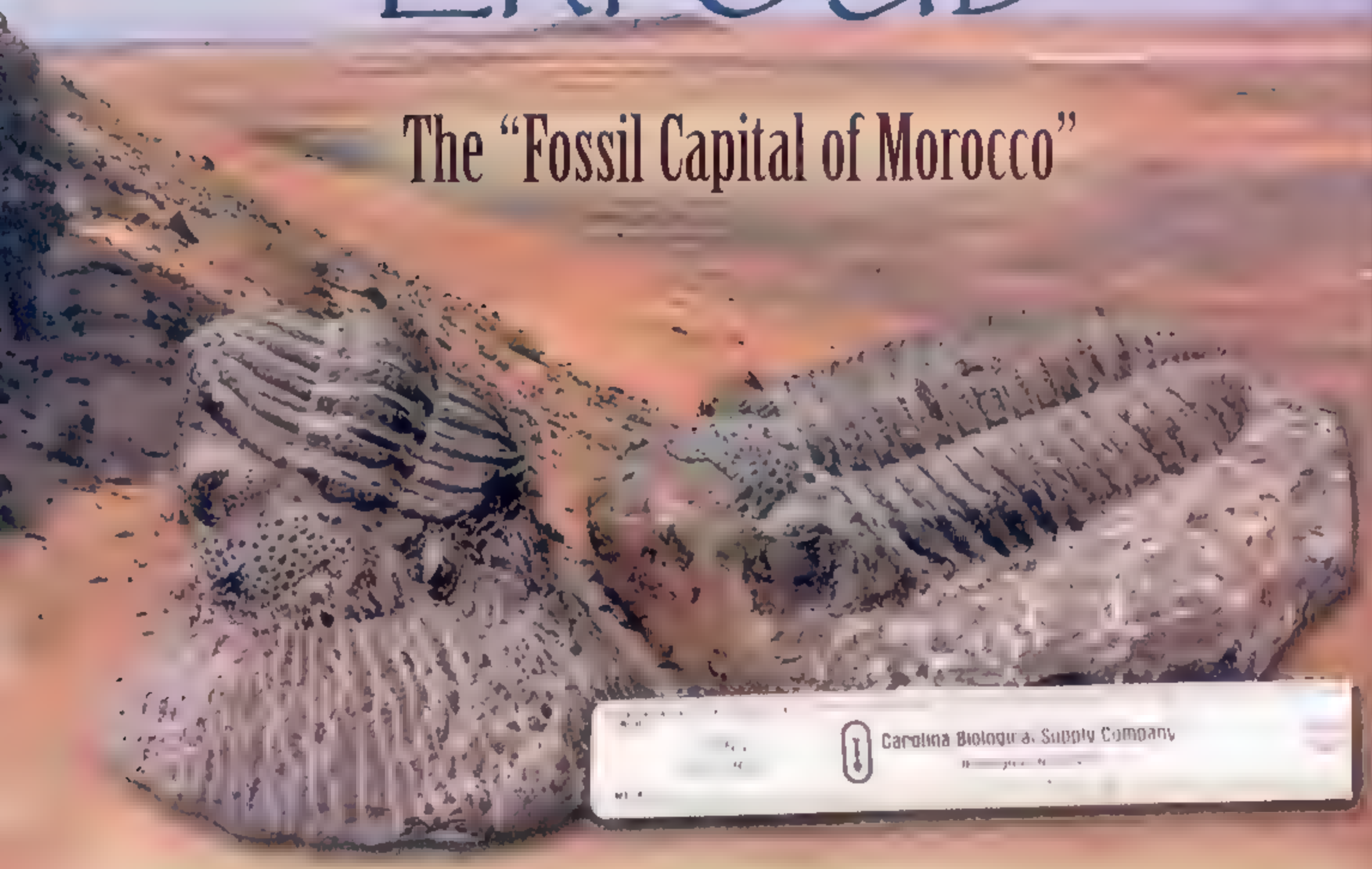
The University of Minnesota has an underground particle physics laboratory at the Soudan underground mine. Huge headframes mark the Soudan Mine and numerous others, but the Soudan Mine is the oldest and deepest. Tours of the underground mine are offered, and a state park is located at Soudan. The Soudan Mine is in the Vermillion Range, the farthest to the northeast. The Cuyuna Range is farthest to the southwest. Like the others, it is a beautiful, forested area of glacial lakes. The last of the ranges to start shipping ore was the Cuyuna.

A much-visited old mine is the Glen Mine, where a 1928 trolley takes visitors to view the gorge and the two-mile-long lake. After that, the quaint trolley pulls up to a historic and authentic mining camp that flourished in 1915. Mountain Iron Historic Overlook offers a view of the first place on the Mesabi iron was discovered. U.S. Steel owns the exact spot and controls the working mines. Tours of the Minntac Taconite Plant are offered by U.S. Steel. The plant covers 3,700 acres, including two pits and a wildlife habitat frequented by wolves, beavers, and the occasional moose. At night, the lakes echo with the wail of loons. Chickadees live in the pines, and a snowy owl is a rare and remarkable sight. The plants, too, are adapted to this climate of snowy winters, ample rain, and high humidity. There are pines, spruce, tamaracks, and aspen, cattails, sphagnum moss, red lilies, wild iris, asters, and the queen of American orchids, the lovely lady's slipper, or moccasin flower.

Am I familiar with this fascinating part of my neighbor state? I lived near Hibbing as a baby, when my father was a teacher there. My memories were only of what my parents had told and retold. So on my honeymoon, I showed Albert the storied land of my early childhood. We stayed in Hibbing several nights. We saw the big hole, Minnesota's Grand Canyon. We picked wild lilies, went fishing and swimming, and listened to the loons. Oh, yes, and found a few agates. Then, when I became the first honorary member of the Midwest Federation in 1963, the show was held in Hibbing. We were allowed to collect in a part of the Hull Rust Mine. I found a heart-shaped bivalve replaced by silvery hematite, a couple of good agates, and a piece of groutite, a mineral first discovered in the iron ranges. When Albert and I started our 30-year travels for minerals and gems, the first place we headed for was—you guessed it—Hibbing.

Fossil Collecting in ERFOUD

The "Fossil Capital of Morocco"



Phacops *is one of the largest and best-known trilobites found near Alnif, southwest of Erfoud.*
(Photos by the author)

by Bob Farrar

The fossil capital of Morocco. Now there's a tall claim. Anyone who is at all familiar with fossils, particularly those available on the commercial market, has probably seen tons of Moroccan fossils. The country produces incredible numbers of fossils in equally incredible variety including dinosaurs, trilobites, sharks, and ammonites. For any one locality to be considered the center for fossils in Morocco, it would really have to be special. In my opinion, though, there is just such a place. It is the town of Erfoud, and it is located in eastern Morocco, between the Atlas Mountains and the Sahara Desert.

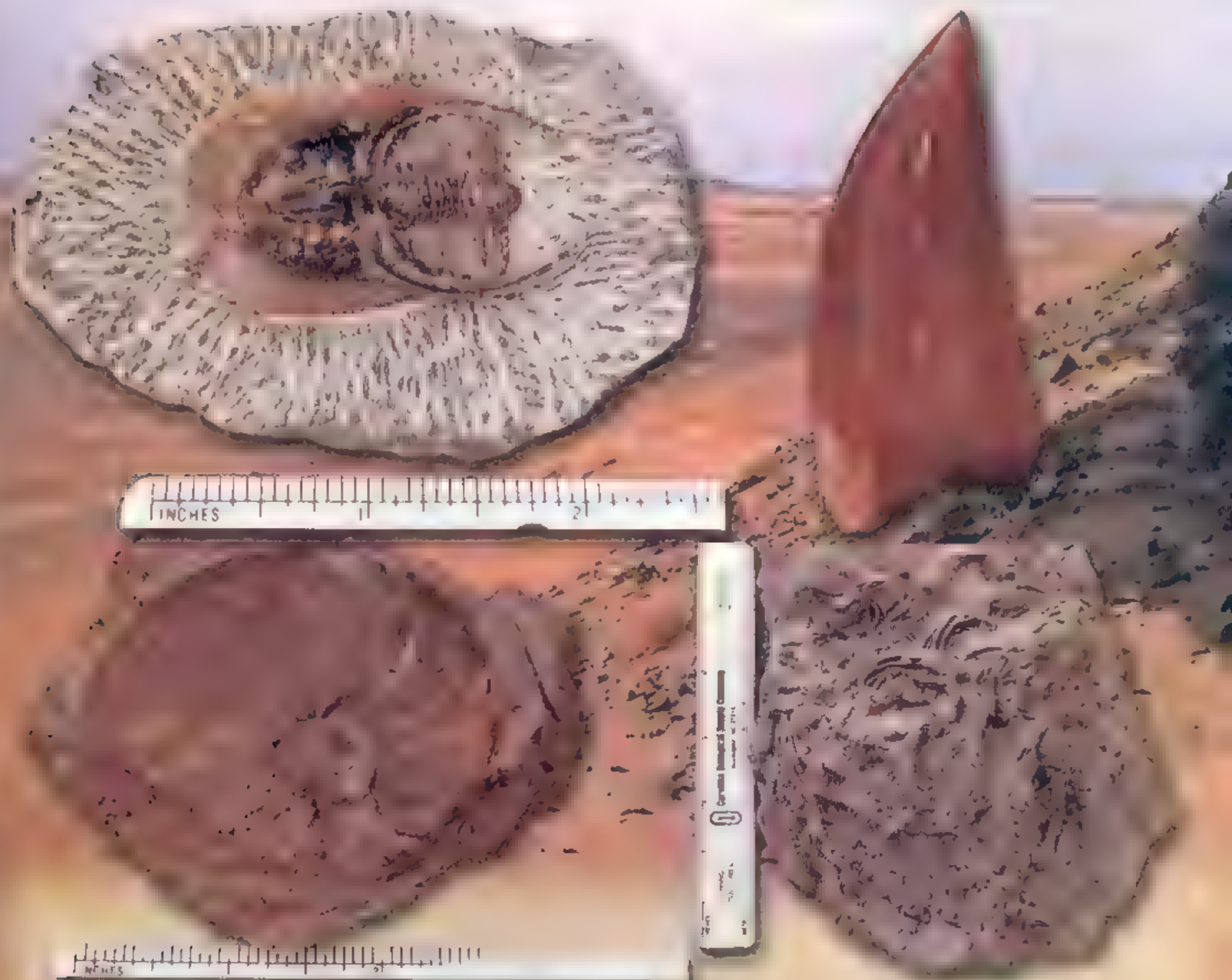
While many fossils are found in the immediate vicinity of Erfoud, the town is also a major center for preparation and trade of fossils found at other localities in the region.

Erfoud is not a large town, having about 7,000 inhabitants. It is easily reached by paved two-lane roads, though getting there usually entails driving a few hundred miles from Casablanca or Rabat on the Atlantic coast. Although the drive is long, it is enjoyable; the route through the Atlas Mountains is very scenic. Erfoud is a main population center of the Tafilalt Oasis, a green area that stands out in stark contrast to the surrounding brown desert. Erfoud and other towns in the area owe their existence to the Ziz River, which brings water down to the desert from the mountains. The main languages spoken around Erfoud are Arabic and Berber, though a number of other languages, including French, Spanish and English, can be heard. It is sometimes said that in Erfoud one hears a "language salad."

Tourism is an important industry in Erfoud. Besides being a lure for fossil collectors, Erfoud is an important jumping-off point for people looking for adventure by four-wheeler or motorcycle in the Sahara Desert. Not far away, near Merzuga, are the dunes of Erg Chebbi, Morocco's only large area of sand dunes. The reddish sands are par-

Harpes, *a less common trilobite from Alnif, superficially resembles the horseshoe crab, but the two animals are not closely related.*

The serrated teeth of the large, predatory dinosaur Carcharodontosaurus saharicus *are among the most sought after fossils from Taouz, near Erfoud.*



The large calyx and arms of the crinoid Scaphycrinites *are found by diggers in the desert near Erfoud.*

Natural specimens of Goniatites, *such as this one from near Erfoud, are rarely seen for sale in Morocco or the United States.*

ticularly scenic at sunset, and at night, the place is great for stargazing. And for a fee, one can take a camel ride on the dunes.

As might be expected, the climate is very dry. Practically all of the available water comes from the river or from wells. It gets quite hot in the summer, while winters are mild. A bit of rain falls in the fall, and sometimes there are sandstorms. The best times to visit Erfoud are the spring and the fall, when temperatures are tolerable. In the winter, one can run into snow on the trip through the Atlas Mountains. I have been to Erfoud twice now, once in the spring, and once in the fall. During the spring trip, Erfoud was having a minor sandstorm. It was not too unpleasant, though I had to be careful to keep the sand out of my camera. My trips were arranged by Sara Mount of Brazil Gem Tours, with local guidance on the latest one by Aissa Aaronson.

At first glance, Erfoud looks like many other towns in Morocco, with many small stores and markets, lots of donkey carts, some vehicles, and many people on foot. This region is one of the more conservative parts of Morocco, so one sees a lot of men in traditional robes and turbans, and women covered head to toe in black. However, there are also lots of people in more western clothing and the modern world is making inroads. I once saw an old man riding a donkey and talking on a cell phone. But what makes it obvious that Erfoud is different is the number of fossil shops. There are dozens of fossil shops in and around Erfoud, as well as shops that stock a few fossils along with their other merchandise. How many rock shops are there in towns and cities in the United States? To see so many shops in a town of 7,000 people shows how important the fossil trade is in Erfoud. The quality of merchandise offered in these shops varies tremendously, from absolute junk and fakes to very fine specimens, and everything in between. Prices also vary greatly, but with a little bargaining, good deals can be had.

continued on next page

Fossil Collecting in Erfoud *from page 81*

Perhaps the most important fossils at least from a commercial standpoint that come from Erfoud itself are those of cephalopods. Cephalopods are a class of mollusks to which octopuses, squids and nautiluses belong. Most of the fossil forms, including those from Erfoud, have chambered shells, and superficially resemble the modern chambered nautilus. There are two main types of cephalopods around Erfoud, one with a coiled shell, usually referred to as *Goniatites*, and one with a straight shell called *Orthoceras*. Both are found in Devonian age limestone formations, and they commonly occur together.

Limestone containing *Orthoceras* and *Goniatites* is quarried in the desert near Erfoud. These fossils are rarely sold in their natural state; they are almost always cut and polished. (I personally like natural fossils, but I never saw a rough Moroccan *Orthoceras* until I actually went there.) Individual fossils may be cut out of the rock and polished, or the matrix with the fossils in it may be polished. Besides specimens, this fossiliferous limestone is cut into a huge variety of decorative objects, from ash trays and bookends to coffee table tops and bathroom sinks.

This brings me to what I consider the dark side of the fossil trade in Erfoud: the conditions under which some of the cutters work. On the outskirts of town, along a dry riverbed, is a cluster of crude shelters where a number of cutters work. Some shelters are made of sheets of plastic or fabric stretched over sticks or ropes, others are made from old junk cars. They barely even provide shade. There cutters use electric and hand tools to cut, shape and polish blocks of limestone into the tabletops and other objects that are sold in town and exported to the United States and other countries. All of the grinding kicks up a great deal of dust. The workers do wear plastic goggles and turbans wrapped around their faces, but I cannot imagine it is sufficient protection. To many of us, polishing rocks is fun, but it can be hard, dirty and, I expect, unhealthful, work for some people.

This is not to say that all of the fossil workers in Erfoud labor under such miserable conditions. Some shops use more modern machinery to cut their material with water to keep the dust down. They may, though, not have a roof over their heads, since it rarely rains it is more practical to use the bright desert sunlight to illuminate the work rather than lamps and electricity.

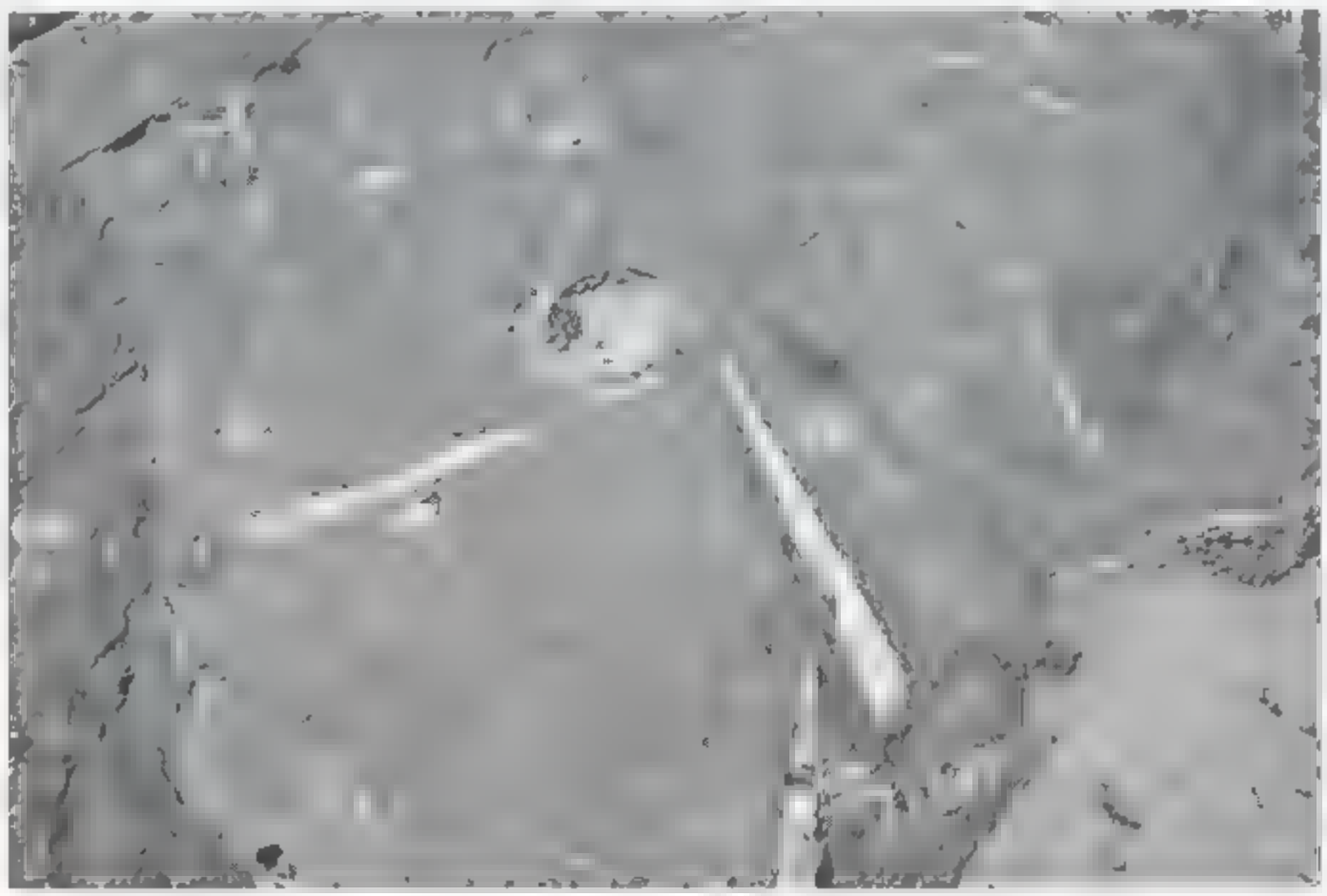
One morning on the most recent trip, Aissa took us to a place where we could collect some fossils. Just outside of Erfoud, we stopped at one of a number of limestone ridges that sat up a couple of hundred feet from the desert. There, fossil-bearing strata are exposed, though sand tends to drift over the lower slopes. After scrambling up the sand-covered slopes, we reached a formation containing small trilobites. No complete trilobites were found that day, but I did get a few study specimens of *Phacops*, which look a lot like ones I've collected in West Virginia. I did, though, find a whole *Goniatites*, partially weathered out of the rock. At last—a natural specimen of *Goniatites*!

Not far from the trilobite and cephalopod locality is another fossil locality that is a strange sight to see. Stretched out across the desert for perhaps two miles is a line of small pits looking for all the world like a line of foxholes on a battlefield. Each hole is square, about 2 yards on a side, and up to 10 feet deep. The holes are spaced a few yards apart. So what are they for? The answer is Silurian age crinoids of the genus *Scaphicrinites*. No one was around the day we were there, though Aissa said that the diggers frequently camp out at the site. There were a few fragments of crinoids and *Orthoceras* lying about for the taking, as well as small selenite crystals and some large but poorly formed septarian nodules.

Most fossil collectors are familiar with crinoids, also known as sea lilies. They are echinoderms, animals related to starfish and sea urchins. Crinoids are not extinct. They still live in today's oceans, but they are not nearly as important as they were hundreds of millions of years ago. Although they are animals, they superficially resemble plants, with roots, a stem, a body, or calyx, and petal-like arms. Usually what is found are sections of the stems, which look like stacks of poker chips. Near Erfoud however, the entire animals can be found, with stems several feet long and tennis ball-size calyces. From these pits, diggers bring out sections of plates sometimes bearing several crinoids. At preparers' shops, the sections of plates are put together and cleaned. Crinoid stem sections are very common fossils. I have collected them by the hundreds. However, whole animals are much harder to find (I've never found one), particularly in such size and abundance as near Erfoud.

In recent years, the fossil market has seen some absolutely spectacular material from an area about 40 miles southeast of Erfoud, near the town of Taouz. I'm talking about dinosaur teeth and other Cretaceous-age vertebrate material. The type most commonly seen on the market is *Spinosaurus*. Movie fans will recognize the *Spinosaurus* as one of the stars of the third Jurassic Park film. This animal walked on two legs, had a sailfin down its back, and weighed up to perhaps 2 tons. Its teeth are conical and sharp-pointed, well adapted for grasping slippery fish, which are thought to have been its main food. I have, though,

continued on page 84



Orthoceras *and* Goniatites *fossils can be seen in rough slabs of limestones. Cutting and polishing are required to bring out fine details.*

Fossil Collecting in Erfoud *from page 82*

also seen these teeth attributed to a different animal, *Suchomimus*. It may take more fossils to tell us for sure. Most sought after, however, are teeth of *Carcharodontosaurus saharicus*, a big predator similar to *Tyrannosaurus rex*. Its teeth may be several inches long and are serrated, like steak knives for cutting flesh. They are much less common than *Spinosaurus* teeth, and command higher prices. Also found at Taouz are sawfish teeth with wicked barbs, *Hybodus* shark spines, crocodile teeth, and dinosaur teeth of uncertain identity.

A lot of the dinosaur material from Taouz moves through Erfoud and the nearby town of Merzuga. When I have seen this material at rock shows, dealers would often have just a few pieces for one to drool over. Imagine my thrill at seeing flat after flat of it. I was able to buy not only fine teeth, but also much less common items such as claws and jaw fragments. All of this was offered for sale in unremarkable little shops that looked like a thousand other little buildings in Morocco. Alissa sure steered us right!

No article on the fossils of Erfoud would be complete without mentioning trilobites, quite possibly the most popular group of fossils from Morocco. Two major trilobite localities lie near Erfoud. About 60 miles southwest of Erfoud is Amtif, a source of an incredible variety of bizarre Devonian age trilobites. Among the best known is *Phacops*, which can reach 5 or 6 inches long. Rarer and weirder trilobites with arrays of various spines and horns include *Ceratarges*, *Dicranurus*, *Psychopyge*, *Leonaspis* and *Otarion*, as well as the horseshoe-shaped *Harpes*. These trilobites are found by cracking open blocks of hard limestone until an indication of a fossil is seen. This rock does not split along planes, it cracks in any direction. Frequently, it will break right through the fossil, the break may be visible only as a thin black line. These rough pieces are taken back to preparers' shops in Erfoud, as well as the nearby town of Rissani. The better preparers use pneumatic hammers to remove the matrix from the top and sides of the specimen, and then glue them back if they were broken in the field. Other shops use simpler tools, even hammers and nails. Specimens are sometimes restored by filled in missing parts with an epoxy resin, reputable shops will limit this to about 15 percent of the specimen. Less reputable shops may fill in more, even the whole piece.

About 40 miles west of Erfoud is the little village of Tarhia. Near Tarhia are Cambrian-age formations that yield some of the largest trilobites you will see anywhere. Two species of large trilobites are found there, *Cambropallas telesto* and *Acadoparadoxides briareus*. *Cambropallas* gets up to about 9 inches long, while *Acadoparadoxides* is even larger, up to 15 inches long. They occur in a matrix of limestone that, unlike that at Amtif, splits easily along bedding planes. If a digger is lucky, he may split a rock and find a specimen completely exposed. More commonly, the slab also breaks across the plane, necessitating some gluing.

An abundance of trilobites is available in the fossil shops of Erfoud, and great numbers are exported to the United States and other countries. One has to be careful, though. While many fine specimens are available, there are also many with excessive restoration, as well as outright fakes. Many fakes are casts made of an epoxy-type resin, and may even have tiny air bubbles visible. They are usually painted black, often with an overly thick coat of paint. Though they are often made in molds made from actual specimens, casts usually do not preserve fine details, such as the facets of the eyes. There may be a crack where the cast was glued to a piece of rock. In the case of *Cambropallas* and *Acadoparadoxides*, especially, many more partial than whole specimens are found. Many of these that are seen for sale have only a small piece of actual specimen, the rest restored. Again, actual specimens will tend to have finer details and sharper edges (as along joints between segments). Buyer, beware!

Erfoud, of course, does not have a monopoly on the fossil trade in Morocco. There are many important fossil localities distant from Erfoud. Though some material may show up in its shops, Erfoud is not the major center of trade of all of them. Among the most important localities are the phosphate deposits of Khouribga, located southeast of Casablanca and northeast of Marrakech. These vast deposits range from Cretaceous to Eocene in age, and yield an abundance of fossils, mostly teeth of mososaurs and various sharks. Also commonly seen in Morocco are cephalopod shells from a variety of localities besides Erfoud, as well as trilobites from other localities. But while not every Moroccan fossil is from, or passes through, Erfoud and the surrounding area, I would say that no other one locality can legitimately lay claim to the title Fossil Capital of Morocco.

FIELD TRIP

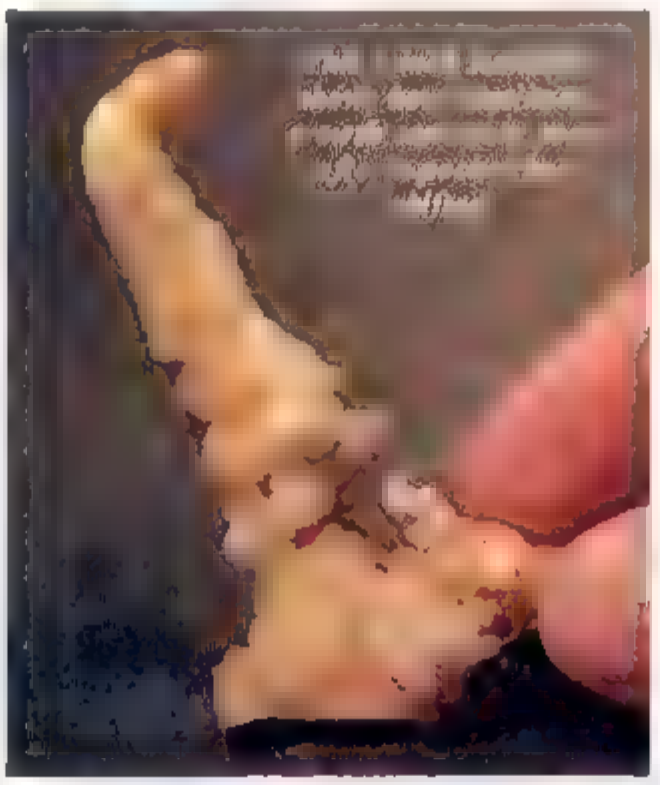
Ilion Gorge Travertine

New York Calcite Can Still Be Collected

by Michael Walter

The closure of mineral collecting localities seems to be more pervasive than ever. Sites we took for granted in our youth are closed by concerned land owners, overgrown by urban sprawl, or kept secret by those few who are still aware of their existence. Amidst all these difficulties, there remain some sites that are accessible to the average rockhound, even in the northeast United States. Near the city of Utica, New York, we can find one such site in a scenic valley south of the town of Ilion.

The location was first brought to my attention in the spring of 2002 by a fellow science teacher and mineral collector. He told me of a stream that cut through shalelike limestone near where he teaches. Within these formations, he was recovering travertine, which is a variety of calcite, and tiny white calcite crystals. I had seen a couple of pieces of this travertine in old collections, so knew the site had been worked for at least several decades. When I looked over the material my friend had recovered, I was not overly encouraged. Being a crystal person myself, these root beer-colored coatings did little to excite me no matter how interesting their form. The calcites were very tiny and there seemed to be no further mineral associations. How lucky it is that first impressions are often misleading.



In fall the same year, I finally got a free day to go take a peek at this location. It was one of those miserable days, cold and wet, when you can't even talk the most loyal collecting partners into venturing out. So when I awoke at 3 a.m. to prepare for the three-and-a-half-hour drive to Ilion, the only company I could roust out was my dog, Scepter. A Labrador retriever's idea of a nice day for a road trip is very flexible.

The directions I was provided with were straightforward, and in no time we were parking the truck just off state Route 51 South. The three-quarters of a mile walk into the dig site was all uphill through a deep valley carved by a small stream, which we paralleled the entire way. The walk was easy because its entire length was paved. This was Jerusalem Hill Road, which is blocked off from vehicular travel at its junction with state Route 51. It was foggy, semidark and drizzly.

At the collecting location, it was not clear where I would start digging. There were spots on both sides of the stream where previous visitors had dug, but they left little to tip me off as to a good starting point. For the first hour or so, I simply scouted out the area on the road side of the stream. After some searching, several possibilities presented themselves. First was a long cylindrical tube that was about a foot wide and extended back into the hillside for at least 20 feet. This was an impressive feature to say the least. When I shone my flashlight back into the tube, I could see that its interior was coated by a thick layer of translucent, amber-colored travertine. The interior was wet, so it made a flashy show. Having opened many large crystal pockets in the past, I am not easily impressed. Viewing the interior of this tube immediately got my heart

Root beer-colored, translucent travertine coatings form bulges and waves on the matrix.

pumping fast! Fingers and wavy sheets of thick travertine glowed in the light like a dream world that can only be created by nature. This was the place to start digging, right? Nope, the tube's entrance was accessible only to the longest chisels. Other than getting a few scraps, the tube was impossible to collect out of. It will probably still be there to wonder over when you visit the site.

The spot I actually settled on was a 5- or 6-inch opening in a sheer rock face approximately 6 feet off the valley floor. Piling some logs and rocks to use as a platform allowed me to climb up to a working level and peer back into the small opening. The void seemed to worm its way back into the hillside, so I thought it a good idea to attempt to widen it to see if there was any potential here. The toughness of this solution-deposited travertine quickly became apparent. Much work with chisels, wedges and hammers is required to dig into the material. The travertine is extremely resistant. It seemed to absorb the energy generated by hammering. The chisels would sink into, but seldom crack, the spongy rock. After about an hour of serious work, I had loosened a block of white travertine. When I finally managed to pull it free, I found myself peering back into a large void that was nearly 5 feet long, a foot high, and at least 4 feet wide. This miniature cave had all the same features that one would see in a real cave. Tiny stalactites hung from the ceiling and dripstone formations had formed on the floor. The walls had coatings of white travertine. Just before heaving the chunk I had removed, I noticed it was in fact a larger complex of intergrown stalactites. I immediately realized I had been a very lucky collector to find a deposit like this one on my first visit to a new location. Or had I?

The rest of the day, I reached back into the opening and carefully extracted the contents. Stalactites were sparsely deposited and easy to remove, while the coatings on the floor and roof of the opening put up a good fight. Scepter kept a good eye on what I was up to as I wrapped these fragile pieces in newspaper for the trip out. Stalactites up to several inches long and plates of travertine up to a foot wide were the treasures that day. Once home, I was also surprised to find that most of the material was both fluorescent and phosphorescent.

As luck would have it, there would be no further trips to Ilion that year. Early snow put an instant end to the collecting season by the next weekend. The following year, however, would provide opportunity for a couple more visits to this interesting site.

My father and Scepter were along for the ride on my second visit in the summer of 2003. We tried to work the tube I had previously found without any luck. Even the specially designed 4- and 6-foot-long chisels I had made were unable to remove the glowing travertine from its home in the hillside. We did have lots of luck collecting thicker deposits of travertine from the same side of the stream the road is on. Between blocks of highly brecciated limestone plates, we found zones where the water had carried travertine. These coatings were up to several inches thick and tan to deep brown in color. The root beer-colored translucent travertine was the most attractive. These coatings formed bulges and waves on the matrix and could be quite aesthetic when properly cleaned.

All the material collected that day was heavily coated with clay. As a result, we hauled back lots of leaverite. Since the water level was lower in the stream, we were also able to collect on the opposite side of the stream, which I had not been able to do on the first visit. It seemed like we were successful in every spot we selected to dig. It appeared that my first visit was not just luck. This site obviously had lots to offer.

Dad and Scepter came along on the third trip to Ilion. As we scouted for the first spot to dig, I noticed something that I failed to give any thought to on the first two visits. On the far side of the stream was a large area of land that was the remnants of a landslide that appeared to have occurred several years prior. The hillside was composed of shattered rock, soil, and rotting trees. It looked like about 100 yards of the hillside had crumbled and slumped down into the valley. The movement had stopped just before the edge of the stream. I scrambled up to the edge of this mass and started poking around in the loose talus. One area had lots of staining similar to the clay staining that was prevalent on the specimens we had collected on our last visit.

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Hoping that this was a seam where there had been travertine, I began digging. Actually, I was mainly rolling chunks of rock free from the pile and allowing them to roll farther down the slope. In no time at all, I was seeing big chunks of greasy red clay, and within them were specimens of travertine. Initially, most of this material was very poor, having been banged up on its slide down the valley wall. It was not long, however, before I began uncovering a large, intact section of what was once a small cave. It appeared that this small cave, which looked to have been about 6 feet long and several feet wide, had been collapsed by the landslide. The inside of the cave must have been filled to capacity by this thick clay, which acted as a cushion to the structures within it upon its demise. Travertine, though very soft, in this situation seemed to have sustained little damage from its tumble down the hill.

As I dug into the clay, it became clear that this find was going to be exceptional. Almost immediately, two large stalactites were pulled from the heavy clay. I estimated the weights of these two goliaths to be approximately 30 and 70 pounds. Soon after, the main area of the void started to produce more manageable-sized stalactites and chunks of flowstone travertine. There were even a few long, thin soda straw stalactites that were fragile, yet still intact. Once cleaned, much of the material showed damage, but as it was coming out of the mud on site, it looked impressive.

Box after box of material was pulled from the clay. We had little idea which pieces were good and which were poor. The clay concealed the specimens so well that we were wrapping specimens based more on shape than anything else. Even when we tried washing the specimens off in the stream, it was difficult to tell which would be quality pieces. I did all the digging and specimen recovery that day, while Dad spent his entire day simply wrapping the specimens for their trip down the valley. Once out of the clay, the pieces were vulnerable to damage, so we took great pains to prep them well for the trip home.

At home, the fun began. The specimens were sprayed with the garden hose to remove the majority of the clay. Next came the tedious job of scrubbing every piece down with a plastic bristle brush to remove any remaining clay. The color of these specimens covered a fairly wide range. Some, like the soda straws, were a creamy white, while others, like the big stalactites, were dark brown or root beer colored. Much of the travertine had a grungy overgrowth, which showed that in its final stages of development, included clay had been deposited along with the travertine. It took a good deal of experimentation to come up with an appropriate method to further clean pieces like this in order to bring out their underlying luster. I found that dipping a toothbrush in vinegar and gently brushing the specimen often removed a good deal of this material. Harsher treatment, such as mild acid dips, was used on some specimens. In most cases, acid treatment was avoided because it created pitting or removed structural details of the formations.

Above: This complex stalactite has mixed colors of travertine. Below: An unusual stalactite developed a small platform midway along its length.

It is my hope that the specimens will speak for themselves. True cave collecting is something I would consider irresponsible and unethical. Preservation of caves should always be attempted. In this situation, I was happy to be able to preserve specimens that, if left where they were, would be lost to the ravages of weathering in a short time. The landslide found on the third collecting trip provided us with a rare collecting opportunity that I am unlikely to be part of again in my lifetime.

Selection of tools for digging at the Ilion travertine site is important. The most important tool is a good wheelbarrow. Because you reach the location along a paved surface, all your tools can be hauled uphill to the location in the wheelbarrow, and tools and specimens can be taken out in the same. There are spots where you can dig in the soil or loose rock, as well as places to dig directly into ledge rock. As a result, all forms of hammers and chisels are handy, as well as digging tools like shovels, trowels, and pick axes. In other words, a large arsenal of equipment can come in handy. Long chisels and screwdrivers are especially useful. Bring plenty of wrapping and packing material, because specimens are often thin or soft. Newspapers, paper towels, and boxes will all be used. Water from natural springs seems to be dripping down many of the banks and ledges even in dry weather, so rain gear could make your collecting day a more pleasant one.

During my few visits to the Ilion Gorge, I have come across a diversity of colors and forms of travertine. It sometimes forms thin coatings on the area rocks, and at other times it is thickly deposited. The material appears to deposit itself much faster than traditional calcite in cave environments. Cave deposits take as much as 100 years to accumulate 1 cubic centimeter of calcite on a single stalactite or stalagmite. The travertine at Ilion, when viewed in cross section in stalactites and flowstone formations, shows annual growth rings similar to those found in trees. I have observed these growth rings carefully and found them to range between several millimeters and a centimeter in thickness, indicating a faster rate of deposition. The rings also have an unusual habit of changing color within the same specimen. Light-yellow to amber to root beer color represents the most common combinations.

The colors and forms of travertine from Ilion Gorge can be quite striking. The luster can range from dull to a bright, almost oily appearance. Sometimes, the surfaces of specimens have a satiny appearance, which gives a holographic effect in good light. Most of the thinner pieces of material are translucent. Specimens of huge proportions can be found. Seams and openings of all sizes appear to be present at the location, so you may recover some large specimens.

I encountered something unusual in a number of the specimens collected in one spot at Ilion that took me some time to figure out. I was running into small stalactites that had sharp bends of about 45 degrees. The bends were present in quite a few specimens from one spot, where they were found loose in the mud and not attached to wall rock. Even those found in clusters of two or

more had the same unusual habit, and in these the bends all went the same direction. It is quite obvious that stalactites, which hang from the ceilings of any openings in the rock, grow in a downward direction due to the pull of gravity on the water that deposits the travertine. These, however, seemed to defy this method of formation. The mystery solved itself when I found a small opening in which similar stalactites were found in situ. They were only a few inches in length at their maximum, but I noticed that their tips were growing downward, while their bodies were tilted. What had caused this unusual change in growth direction was a displacement of the entire void. The opening was located in a large block of rock that had tilted downhill due to slumping of the surrounding land.

Throughout the gorge, one can see enormous blocks, almost the size of homes, that have broken free and begun to roll down into the valley. If there are opening within these, the direction of growth for structures inside those openings changes. One might think that the source of water for deposition of travertine would in turn be cut off. Sometimes, that does not seem to be the case. Springs are everywhere, and they often seem to continue to drip into these blocks, allowing for solution flow and deposition to continue.

As for calcite crystals, to date, I have found none. When encountered, they appear as white dogtooth crystals that form in tiny clusters and druses on the travertine. Their maximum size seems to only reach a few millimeters.

To reach the Ilion Gorge, one can take Interstate 90 Exit 30 for Herkimer. Head east on state Route 5S for Ilion, and take the first of two exits into the town of Ilion. This exit takes you directly to an intersection with state Route 51. Follow state Route 51 south through town and continue on it for about 5.8 miles. On your right, you will see a gate blocking the entrance to Jerusalem Hill Road. The road is blocked because the town's drinking water supply comes from this stream. Follow the paved surface uphill for three-quarters of a mile. At this point, you will see numerous locations where you can collect. Take great care navigating on the scree and loose boulders. Overhanging rock can be seen on the banks of the opposite side of the stream from the road. Beware of potential rock falls in this area. In the spring, the stream will be high and difficult or impossible to cross. Both sides of the stream offer opportunities for finding quality travertine specimens.

ON the ROCKS

by Bob Jones

Mineral Museums Everyone Should See

It is inevitable that, with all the articles I write, I'll make mistakes or include incorrect information about a mineral or mine. Such was the case in the Frugal Collector article "Smithsonite" in the July 2004 issue of *Rock & Gem* (page 14). I mistakenly reported that the famous classic smithsonite locality near Magdalena, New Mexico, the Kelly Mine, had been given to the New Mexico Bureau of Mines and Mineral Resources of New Mexico Tech by the owner, New Jersey Zinc Co. It was not! New Jersey Zinc did give New Mexico Tech the Waldo Mine, located close by the Kelly Mine. The Waldo is used for training and student study. But New Jersey Zinc hung on to the Kelly for a time before finally selling it.

The Kelly Mine is now owned by Millennium Inc., which bought it from New Jersey Zinc in August 1993. Tony Otero of Magdalena, whose name is very familiar to everyone who has collected for years, facilitated the purchase of the Kelly for Millennium. Tony was one of the great specimen collector/dealers who was especially successful in bring superb smithsonites to grass from the Kelly. For a time, Tony was responsible for deciding who might go into the mine and collect. Later, Tony's sister Bennie handled requests for collecting permits while the Kelly was under lease from New Jersey Zinc. But that is no longer the case, and collecting there is not allowed at all. Now that Millennium owns the property, everything is closed down for evaluation. Readers can access current information and learn the status of this country's great smithsonite locality on the Web site www.mmmgems.com.

My apologies to New Mexico Tech and to Millennium Inc. for the error in the smithsonite article. I suspect we will be hearing more from Millennium about this superb specimen locality in future issues.

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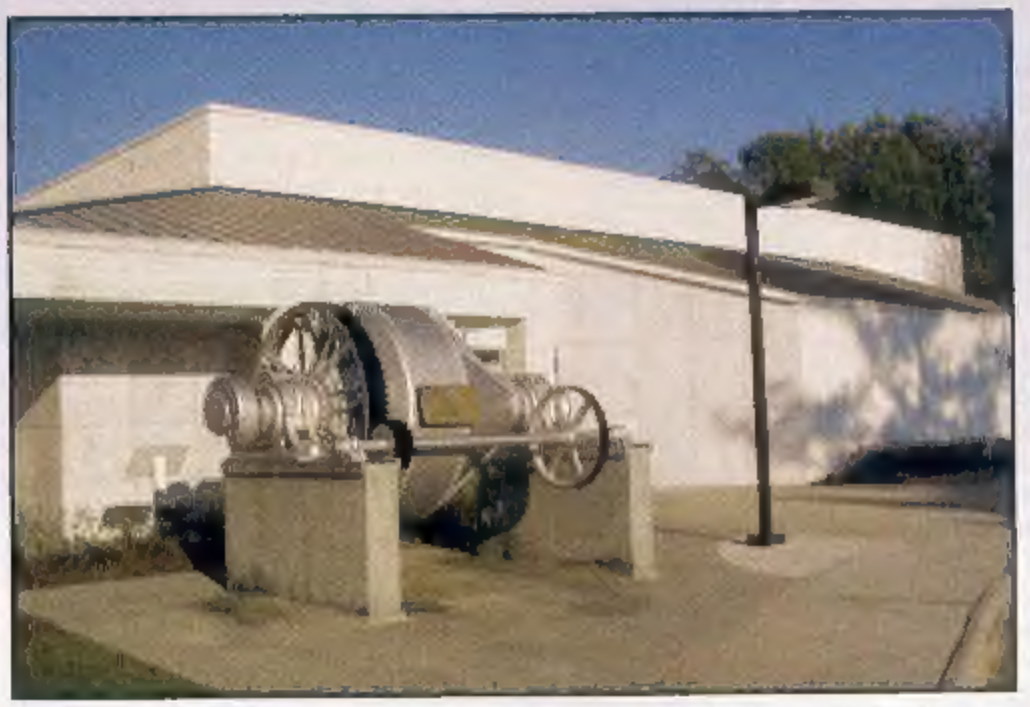
I see folks in the Northwest can now collect quality sunstone in south-central Oregon. The Dust Devil Mining Co. is operating a mine property that is open to the public during the summer. Collectors are allowed to work the dumps and may keep the clear and slightly schillered stones they find. When a superb piece of gem rough is found, the collector pays what is termed "below wholesale" for it.

Sunstone is one of the gem varieties of feldspar, usually a variety of oligoclase, and occurs as a filling in small vugs in basalt. Its alter ego, moonstone, can have a superb blue schiller. The cause of color in moonstone is the micro-thin lamellar plates of crystals that grow alternately, creating an interference of light we call schiller.

Sunstone from Oregon shows the schiller effect, but the color is usually a bright gold to red. In fact, the Dust Devil Mine produces an impressive variety of colors ranging from pink to peach. Orange, various shades of red, and in rare cases green or blue are seen shimmering within the gem. Most pieces show just one color, but occasionally a stone shows two or three colors. Some even change color when rotated. With a hardness of Mohs 6, sunstone is an excellent jewelry gem.

The cause of color in the Dust Devil sunstones is closely related to microscopic bits of native copper locked in the feldspar. This is very unusual, since most sunstones derive their color from bits of hematite or goethite.

You can learn more about the Dust Devil Mining Co. at its Web sites, www.dustdevilmining.com or www.oregon-sunstone.com.



The Hardinge Conical Mill, the first marble-grinding machine in the country, occupies a place of honor outside the Weinman Museum. (Photo courtesy the Weinman Museum)

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I had a chance to visit two excellent southern museums while involved in the Eastern Federation of Mineralogical Societies retreat at Wildacres, near Little Switzerland, North Carolina. While in Asheville, I dropped in on the Colburn Museum of Gems and Minerals, a delightful small mineral and gem museum located at Pack Square in the heart of Asheville.

The Colburn Museum is not large, but has some rather elegant displays. Naturally, there are North Carolina emeralds and hiddenite. The hiddenite crystals are particularly fine and include a very nice, small cut gem. There are, in fact, several gem displays, including one that matches natural crystals with faceted gems of the same material. The "What is a Gem?" display is most interesting. Of course, if you like big gems, try the Colburn aquamarine crystal, which weighs in at 853,800 carats, or 376 pounds. The color of this huge Brazilian gem ranges from pale to good blue, and much of the crystal is gemmy! It is accompanied by a small 6 carat blue aquamarine gem cut from a fragment of the same huge crystal.

Educational displays are part of the Colburn effort. One room is entirely devoted to the Earth and features volcanics, plate tectonics, and interactive computer displays.

Just before visiting the Colburn Museum I had been given a chance to spend time at the William Weinman Mineral Museum near Cartersville, Georgia just northwest of Atlanta where I gave a talk. The Weinman and several nearby museums are well worth visiting when you travel.

Visiting the Weinman really opened my eyes to the minerals of Georgia. For example, I did not realize I had actually eaten some of Georgia's finest barite! You might have had the pleasure, too, if you have ever had to drink a barium cocktail so your stomach and esophagus could be examined with a fluoroscope for signs of acid reflux disease. And if you have not swallowed Georgia barite, which is used in virtually all such testing, you have undoubtedly used some of its limestone in the form of finely ground filler in slick paper, toothpaste, or another industrial product. Much of Weinman's wealth came from his development of grinding

Startling red crystals of lead chromate (crocoite) from Dundas, Tasmania, are on display in the Weinman Museum. (Julain Gray photo, courtesy the Weinman Museum)

pure limestone into exceptionally fine powder for industrial use. Of interest to museum visitors is one of Weinman's original grinders, sitting by the museum's front door. You may also have enjoyed some of Georgia's kaolin clay. Georgia produces about 90 percent of all the pure, fine-ground clay used in medicinal products useful in treating diarrhea.

Be that as it may, the Weinman Museum boasts some wonderful displays of Georgia industrial minerals like barite, rutile, calcite, clay, and kyanite, to name a few. While these minerals are largely used in massive form, the quarries that produce them have also produced superb crystals.

What makes the Weinman Museum really special is that it was the idea of the people of the city of Cartersville. Since the Barstow County region is rich in mining and mineral heritage, city and county leadership has a policy of supporting several local museums, including the Weinman Museum. This idea would be well applied in other cities and counties.

In 1978, the Cartersville Tourism and Industry Council voted to build the Weinman Museum. Three years later, the William Weinman family agreed to donate $300,000 to help construction. With this and other donations, the museum was built and opened in 1983. Initially, the museum was run by the Cartersville Bartow Convention and Visitor's Bureau. In 1995, it was placed under the guidance of the Etowah Foundation, a move that changed the direction of the museum to place greater emphasis on educational activities and programs. Financial support has continued to be provided by the Foundation, which is made up of people interested in the museum's welfare.

Today, the educational opportunities provided by the museum are considerable, thanks to Director/Curator Jose Santamaria and his assistant, Terry Everett. Tens of thousands of school children have gone through the museum, not just to stare at static exhibits, but also to learn from hands-on activities that include gold panning, fossil searching, and mineral testing. There is an outdoor mineral garden, a walk-through cave display, and a Discovery Room, where a variety of activities keep kids interested. A case shows a nice variety of gold specimens from worldwide localities. When group sessions are planned, a classroom is available where short lectures and orientation sessions are held. The museum also offers training and orientation programs and classes for teachers interested in extending their knowledge of the earth sciences.

The mineral displays are superb. Many feature fine specimens from the collections of Frank Mayo and Gil Withers, two noted Georgia collectors. In addition, local industries have made available amazing specimens unearthed during the operation of quarries and mines. These are joined by displays of the natural elements, the physical properties of minerals, and even a fluorescent mineral exhibit. As you walk into the lobby of the museum, you are greeted by one of those donated specimens, a group of calcite crystals nearly 4 feet across and weighing several hundred pounds. Some of the crystals are as much as 3 inches across the termination. The crystals are slightly pink and perfectly undamaged.

Most collectors have heard of Georgia's Graves Mountain rutiles. These amazing crystals occur with kyanite and hematite. The rutile crystals often have a brilliant luster, and are sharp and of generous size. They can be several inches across and are often twinned. They are a very attractive, rich mahogany color. The crystals are usually embedded in hematite, but are also associated with the kyanite of the deposit.

Though this deposit has been commercially worked for decades, there are still crystals to be had. In fact, though the mine is shut down, it is open for small-group and individual collecting. The company has a watchman on the property and collectors can arrange with him to dig.

Barite was mentioned as an important industrial mineral, but I was quite unaware of the superb crystals that also occur in the barite veins. The museum boasts a very fine display of cockscomb barites, clusters of 2- and 3-inch crystals in diverging sprays as much as 6 or 7 inches across. The color of these lovely crystals ranges from gray to pale blue.

Still another display consists of fine blue kyanite in blades several inches long. Kyanite is one of Georgia's very important industrial minerals, and Georgia kyanite rivals pieces from Brazil.

The state gem of Georgia is staurolite, so you can expect to see a fine display of this "fairy-cross" mineral. Found in sharp, orthorhombic crystals, its name means "cross" because it most often is found as simple right-angle twins or a pair of crystals slanted at a nearly 60-degree twinning angle. Usually, crystals are under 2 inches in length, but their sharp form and twinning habit make them attractive gift shop minerals. Quantities of the better crystals are best seen partially embedded in the dense schist where they formed.

Though the Weinman Museum focuses on minerals, there is also a very fine fossil room, which boasted a huge skeleton cast on loan from the Fernbank Museum of Natural History when I visited. The fossil, a Platybelodon, is better known as a shovel tusk elephant. The original was excavated in China and is 15 million years old. On permanent display are such things as a huge fossil shark tooth and part of a series of fossil displays representing the ancient history of the state. The item that caught my attention was a clump of actual wooly mammoth hair from Siberia, where several complete creatures have been found frozen in time by the last Ice Age.

Cartersville and Bartow County support several other fascinating museums in the Cartersville area. Nearby is the Kingston Saltpeter Cave Preserve, where saltpeter (potassium nitrate to chemists) was mined, first by local Indians, then during the War of 1812 and the Civil War. All sorts of fossils have been found in the cave, including a giant armadillo, mastodon, peccary (wild pig), and even a jaguar! The Saltpeter Cave Preserve is in the Knox dolomite rock formations. The Knox series also offers some very interesting multicolored agates any collector would like to check out!

The Booth Western Art Museum and the Bartow History Center which covers the area's history beginning with the Cherokee Indians, are also worth checking out. For environmentalists, there is the Margaret and Luke Pettit Environmental Preserve, an outdoor teaching center of educational and scientific value and a safe haven for endangered species.

The next time you're rockhounding in the western Carolinas, drop down to Cartersville and enjoy some really fine local museums.